Practical
KNOWLEDGE
For ALL

Volume
FIVE

*

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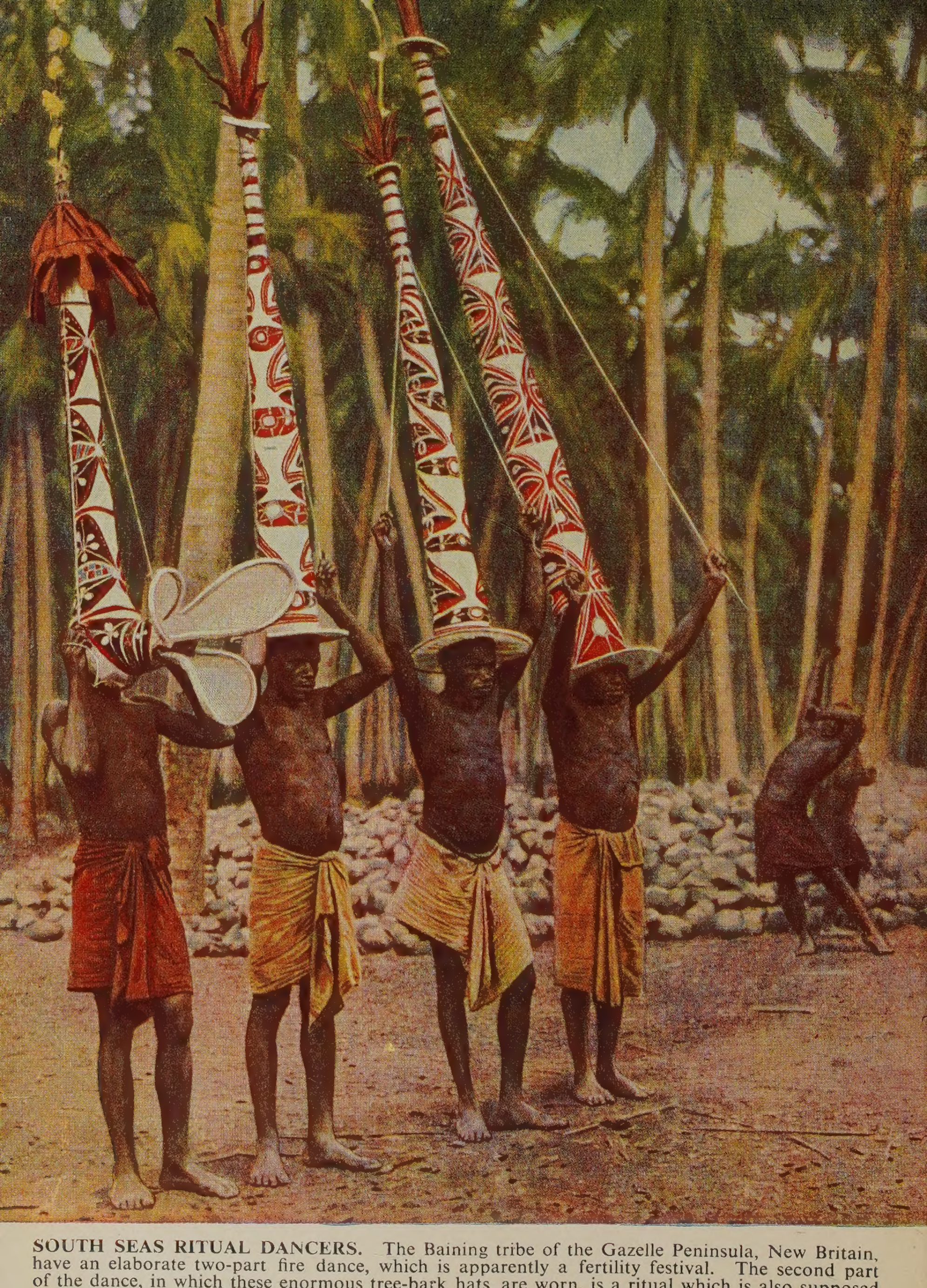
The attention of readers using this, the latest, edition of PRACTICAL KNOWLEDGE FOR ALL is drawn to the fact that the most recent information concerning certain of the Courses is to be found under the above heading at the end of Volume VI.



SOUTH SEAS RITUAL DANCERS. The Baining tribe of the Gazelle Peninsula, New Britain, have an elaborate two-part fire dance, which is apparently a fertility festival. The second part of the dance, in which these enormous tree-bark hats are worn, is a ritual which is also supposed to affect the weather and other conditions. Such rituals are common in many primitive peoples.

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Edited by
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VOLUME FIVE

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ANTHROPOLOGY

MAN himself, his nature, his manners and customs, his primitive arts and crafts, forms the subject of this Course of Lessons. Man not as the citizen of an urbanized and industrialized community, but in the primitive relations of clan and tribe, in the universal experiences of birth and puberty, marriage and parenthood, in health and sickness and within the grim portals of death. Many others of our Courses have their bearings on anthropological study, in particular ARCHAEOLOGY (*Vol. I*), PSYCHOLOGY (*Vol. II*), *and* SOCIAL HISTORY (*Vol. III*).

21 LESSONS

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LESSON ONE

The Study of Mankind

ANTHROPOLOGY, the study of mankind considered in its widest sense, is almost a universal science as far as our terrestrial globe is concerned. Its tremendous scope has led to specialization, but the many branches have connecting twigs and all are in touch with sister sciences.

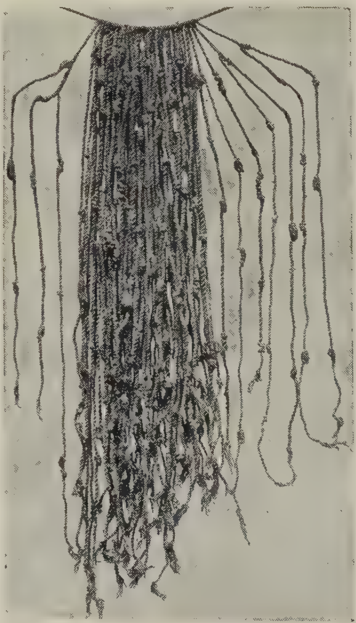
Divisions of the Science. *Physical anthropology* deals with the study of Man as an animal, his relation to the rest of the animate creation, his bodily structure and variations, the development of types, and the reaction of these to various environments and local food products and their comparative resistance to climate and disease. Here must be sought the aid of biology, anatomy, histology, bacteriology, geology, geography, entomology, botany and archaeology, and the young study of Mendelism. Nearly all of these are the subjects of separate Courses in this work.

Social anthropology deals with man as a herd animal, with relationship, marriage, inheritance, intertribal relations, war, trade and religion. In most of these subjects reference must be made to psychology, to which a separate Course is devoted in Vol. II. Social History (Vol. III) may also be referred to.

Technology regards Man as a worker, tool user and cultivator, and studies his handicrafts, from the most primitive stone implement to the Jacquard loom, the aeroplane and the motor. This branch of anthropology is in close touch with most of the physical sciences, especially geology, botany, chemistry, and so forth. Further, it overlaps social anthropology to a very large extent. It is impossible to study the one without being continually brought in contact with the other; in fact, the distinction is purely academic. In the weaving of the border of a Maori cloak, the operator sang a song. If one word was omitted or mispronounced the whole of the work had to be recommenced, because, as we should say, the 'luck' was broken. In the case of many crafts, e.g. iron working in Africa and house construction and canoe building in Oceania, only certain clans or families who know the traditional songs and tabus are allowed to perform the necessary operations.

So we have the queer phenomenon that in certain of the Pacific islands the crafts of weaving and even of canoe building have disappeared, because the families who had the right and knew the ritual have died out. Ritual, heredity and craftsmanship are inseparable, and cannot be studied with profit except in mutual relationship. The guilds and companies of the city of London are a case in point, and so, too, is freemasonry, which is founded on stonecraft.

Other anthropological terms, ethnography and ethnology, have given rise to some confusion of ideas, because of loose definition. To speak generally, *Ethnography* takes the individual as its unit and the tribal group as its horizon. It is descriptive, as the term implies, and deals both with the technological and sociological aspects. *Ethnology* is comparative and takes the tribe as its unit and the world as its horizon, drawing its data from ethnography. Ethnology touches the fringe of physical anthropology, but a certain confusion has been introduced owing to the use of the word *ethnologie* in France to mean physical anthropology pure and simple.



PERUVIAN 'QUIPPU.' Although they had evolved no form of writing, the Peruvians of Inca times used a system of knotted cords for recording accounts, messages, and even events. More is said of these aids to memory in the Lesson on Writing in p. 59.

British Museum

When Did Civilization Begin? The word civilization is generally used as implying a clean cut with the primitive. But where does the cut occur? A convenient word 'barbarism' has been used, associated with the invention of some form of writing. But writing is not necessarily a standard of human progress. The early Maya of Central America used a very highly-developed hieroglyphic script, wove elaborate garments, made excellent pottery, erected fine stone buildings, but knew no metals. The Peruvians before the invasion of the Spanish *conquistadores* were weavers, and if the textile art vanished from the Old World it could be reconstructed from the ancient cemeteries of Peru. Their pottery, masonry and social system were superior in technique to those of the Maya, but they had no writing, though they registered their accounts by means of a system of knotted cords. The very primitive Battak people of Sumatra has a script, but its culture cannot compare with the early cultures of Central and South America.

Our so-called civilization is not immune from anthropological rules. The development of modern transport has made a great difference to human life; but not more, in essentials, than the discovery of iron, or the invention of the bow. Civilization began with the tendency of man to wander, often perforce, owing to climatic changes and the necessity of following migratory food animals. Contact with other human groups and intermarriage—often forcible—spread the knowledge of arts and crafts, and especially of food plants. Maize is an example. Before Columbus no particle of maize had left America, but within a century it had become the staple food of half Africa. Migrations, frequently resulting in mixture of races and cultural contact, bring anthropology into close relation with history.

Importance of Tradition. Anthropology is a young science; and historical literature, until recently, has taken little regard of it. Hitherto it has been dependent mainly on written records, and too little attention has been paid to tradition on the one side and to the prejudices of the individual historian on the other. Where writing does not exist, sheer memory is the substitute. In New Zealand, for instance, lads of high birth were educated in a kind of school, where they were taught the history of the nation. They had to be word-perfect, and it is on record that a chief could recite, from memory, genealogies, historical events, and tradition (all in set terms) which on paper would have filled a volume equalling in size the Christian Bible. The sterotyped memorial record is also known in Africa, where, to give one instance, a Bushongo chief, on his installation, has to recite the history of the tribe, together with the names of all his predecessors, carefully supervised and sometimes corrected by the older men.

MAYA RAIN GOD. Owing to the importance of rain for the maize crops. the rain god, portrayed with the snout of a tapir, the 'lightning animal,' was one of the chief Maya divinities.

Photo, Dr. A. P. Maudslay

Conservatism of Mankind. Mankind, ready to accept from its neighbours a new food plant or a new labour-saving appliance, is tremendously conservative. The past is always present in today, as in the change of function of tools and ornaments diverted from their original purpose. Throughout West Africa, Central Europe, and the Malay States the stone implements which are discovered, relics of a stone culture of which the present population has no knowledge, are locally regarded as thunderbolts. In New Guinea stone pestles have been found which the natives in our historical times use as charms, burying them in the plantations in order to produce fertility. The native of New Guinea, as far as our knowledge goes, uses no food which requires the employment of a pestle; but the survival of the implement, diverted to a different use, suggests a previous culture which was based on different economic lines.

As regards the application of the science to present and future needs of one particular group of peoples, there is much to be said. Anthropology is not a mere record of the queer customs of savages, a collection of interesting stories about peoples whose ways of living and modes of thought are so very different from our own. It provides a basis for the inevitable contact between peoples of different cultures under modern conditions.

Northerners may claim priority of colonization, but the claim is not founded on fact. It is true that the Norsemen discovered Greenland, and perhaps America; but colonization, as we know it historically, belongs to the period of Alexander the Great, when many of his men settled in north-west India and introduced Greek art. There are other instances of colonization, interesting from the point of view of culture contact—the Chinese, and much more recently the Russians, in Turkestan, the Portuguese in West Africa and the East Indies, the Dutch in South Africa, the French and British in India, and so forth. In the matter of administering peoples whose mode of life differs, who think on rather different lines, anthropology can be of great assistance.

Mistakes in Interpretation. It is possible for a young administrator to make a mistake, even in mere etiquette, which takes years to retrieve. Again, no native respects a white administrator simply because he is white. He has the power of the purse and magic beyond native comprehension, but his personal prestige rests solely on his own personality. Mistakes have occurred which could have been avoided by a short series of lectures on primitive sociology, e.g. the Maori war of 1845, which resulted from the cutting down of a British flag-pole at Kororeka in New Zealand. There had been some question of land tenure, as between natives and settlers, and the native method of claiming land was to set up a pole. A rival claimant would enter his protest by cutting it down, and the matter was then argued out. But in England the cutting of the flag mast was regarded as an insult to the British flag, and a prolonged war was the result.

Again, the excuse for the outbreak in 1900 of the Boxer trouble in Pekin was the addition of a steeple to a missionary chapel in the city. According to Chinese belief, the souls of the revered dead pass through the air at a low altitude, and buildings must not be erected which impede their progress. Hence in the rising the chapel was the first object of attack.

Instances could be multiplied, especially in connexion with the contact of European ideas and religion with the ideas and religion of peoples belonging to what we term the lower cultures. In the forcible abolition of any single practice, the reaction on the local sociological structure is difficult to foresee.

When a 'Club House' was Abolished. In the tropics there are no infant foods, and the period of suckling is prolonged for three years or so. During that time a man may not approach his wife, because any form of intimacy is believed to affect the health of the child, and the wife's relations might claim heavy compensation. But in Melanesia, for instance, the man finds a refuge in the club house. Here the old men, the younger men who have not another wife, and initiates, foregather and perform certain ceremonies on the lines of our masonry. Boys at the age of puberty were supposed, as prospective initiates, to sleep there under the supervision of their elders. Unfortunately, in at least one instance, the club house was officially abolished, on the plea of missionaries that it was a pagan institution. In consequence, the married men had to go back to their huts and, being human, could not resist the proximity of their wives. As a result 'unwanted' children were born, and the habit of infanticide crept in. The young lads of the village, no longer subjected to the supervision of the elders, went in search of the young girls, and the entire, very rigorous morality of a clean-living community went to pieces. A slight knowledge of anthropology would have given a warning against the interference with age-old institutions which, however strange, have a use and a meaning.

The late A. C. Haddon, in his Conway Memorial Lecture, delivered in 1921, mentioned a book, which was published as late as 1900 in America, on the title page of which occur the words: 'The negro, a beast, but created with articulate speech, and hands, that he may be of service to his master, the white man.' The publishers were the American Book and Bible House of St. Louis, Mo. The example has no bearing on the scientific study of social anthropology, but it is interesting as a survival of an attitude, often mutual, between peoples of different cultures, when the development of means of transport brought into contact populations who had built up their social and economic life on different lines.

Savage Culture. Many explorers estimated the mental capacity of a tribe on arithmetical grounds, overlooking the fact that the savage has no use for high numbers and rarely any words for them. But even a man who knew no word for a number higher than five was perfectly aware of the difference between five goats and six goats. Our colour vocabulary is singularly small, and we have to differentiate between different shades of blue, for example, by a qualifying adjective. But that does not mean we are unaware of the difference. On the whole, primitive languages are lacking in generic terms. The Englishman, for instance, will say grass where the Bantu word would give the specific name of the particular grass. It is true that a general term, *matiti*, meaning herbage, exists, but it is only used in speaking to Europeans and other ignorant people.

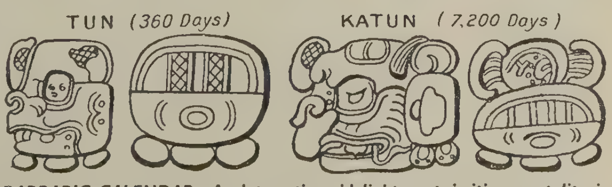
In the development of our own particular culture, we have neglected certain faculties which are vital to others. One instance is the sense of hearing. It is extremely difficult for a European to locate the direction of a sudden sound. But any West African youth will not only give the direction of a guinea fowl which has uttered a short sharp cry, but will indicate the bush in which it is perching. Human faculties have been developed to cope with immediate needs; and the white man, without native retainers, would be as helpless in a savage country as a savage in a civilized city. Not long ago a theory was put forward in Europe that the primitive peoples thought on planes so different from those of Europeans that mutual understanding was impossible. This theory breaks down in practice, because, if it were correct, there could be no intercommunication and no colonization.

The mental process of the human species is the same, but human needs are varied by local conditions. Even in mathematics there is no need for a decimal system, as is proved by the fact that the Maya in Central America evolved a calendar, which was based on a vigesimal (twenty the basis) system.

Man, in whatever environment, he may be, faces certain problems to which he has to accommodate himself, and which he has to explain. The human mind has this in common, that it resents a mental cul-de-sac. There must be some explanation, and that explanation can be provided only from local knowledge and experience. It is a question of cause and effect. The effect is obvious, but the cause has to be sought, and remedied. It is not so many years since malaria was supposed to be due to miasma produced by the exhalations of tropical swamps. The part played by the mosquito is a very recent discovery, and that is only one instance of many such in the development of European medical science.

Primitive Logic. But primitive logic is, in the environment, equally sound. When the Boers, in the 1830s, made the Great Trek across the Vaal, they travelled in wagons and encountered a people who had never seen wheeled vehicles before. For miles the population followed them with cries of delight, cheering the small wheels which, revolving much faster, made so gallant an effort to keep up with the big wheels. When the railway was finally laid from the coast of Kenya to Nairobi, and the first train went up, fuelled with wood, the natives had their own explanation of the engine. It was an animal, which ate wood; it suffered from malaria, because when it groaned the white medicine man put oil on its joints; it hated work, because it always screamed before it started to pull the wagons.

There are many such instances of primitive logic: the boy who, on his first introduction to a gun, firmly believed that the birds came out of the barrel; or the boy in the mission school who would not accept the



***BARBARIC CALENDAR.** An interesting sidelight on primitive mentality is thrown by the Maya calendar, in which the time-unit was a 'month' of 20 named days, running concurrently with a 'week' of 13 numbered days. Some of the day and month signs are shown above, together with those for a 'tun' and 'katun.'*

British Museum, Guide to the Maya Sculptures proposition that 'the whole was bigger than the part,' because he had seen so many squirrels whose tails were bigger than their bodies. When we think back to our own childhood, we remember how we made our own explanations of social, and especially sexual, phenomena, which were quite logical according to our knowledge.

White Man's Magic. But when native knowledge has become incorporated in a social system and religion, it is unwise to upset the premises on which it is based, and the danger of disrupting a perfectly satisfactory society, attuned to its environment, is great. Various conjuring tricks, exhibited by white explorers, have so often missed their effect because they are simply attributed to white man's magic.

One instance may be given. When, years ago, a group of pygmies from the Ituri forest were brought over to England by Col. Harrison, they were not in the least impressed by motor cars and London as a whole. What really astonished them was a visit to the Zoological Gardens, where they saw an elephant, domesticated, and carrying men. This experience impinged on their own knowledge of the elephant as the great beast of the jungle and untamable. This represented power to them. The rest was magic. and being accustomed to magic, as a belief, the other experiences had little effect.

LESSON TWO

Magical Rites

MAN, in his progress, has always been brought in contact with natural phenomena and forces, literally superhuman, which he has tried to explain to himself and to control or to propitiate. The terms magic and religion belong to a late phase of human development and it is difficult to say where one ends and the other begins. Many established religions have included magical practices in their ritual, and many magical practices are survivals of a submerged religion.

No definitions—and there are many—of magic and religion respectively are satisfactory; but, for purposes of study, perhaps it is best to regard magic as an attempt to *compel* the unknown powers, while religion, on the other hand, tries to *appease* them. But the overlapping defies definition. The distinction, like beauty, lies in the eye of the beholder; and, in a community of individuals widely differentiated by education and experience, what is magic to the one is symbolism to the other. Symbolism, in fact, provides the link. In the most highly organized religions many ritual practices are regarded differently by members of the same congregation as symbolic or efficacious. The two points of view have led, in modern history, to the most bitter dissensions. Yet symbolism is a survival of primitive belief, and usually of what we term magic.

Imitative Magic. Many magical and ritual practices fall under the head of what is termed in the classroom imitative magic. These practices are world-wide, and are based on the logical processes of the human mind and the confusion of cause and effect. A paramount example is provided by rain-making ceremonies. By imitating the phenomena of rain, rain may be compelled. The late A. C. Haddon gave one of the best examples, relating to Murray Island in Torres Strait. A stone image was buried with chopped leaves, and water poured over the object. Leaves and sea shells, both suggesting water, were heaped over. Coconut-leaf screens, representing thunder clouds, were erected around the grave; a lighted torch brandished, symbolizing lightning; and a bamboo clapper imitated the thunder. Under this compelling influence rain could not but come! (*See* Colour Frontis. to this Vol.)

One of the most terrible sacrifices in the world, which involved the flaying of the victim and the wearing of the flayed skin by the captor of the prisoner, was practised by the Aztecs of Mexico, in the ceremonies held in honour of Xipe, the god of young vegetation. The flayed skins were worn for the duration of the ceremonies, and were then discarded simultaneously. The wearer of the dead skin represented winter vegetation, apparently dead, but containing within it the germ of life. The ceremonial casting off of the dead covering was supposed to assist in the regermination of vegetable food-plants.

Ceremonies believed, by imitation, to assist in the procreation of food animals are, or have been, widely practised by primitive hunting peoples throughout the world. The buffalo ceremonies of many of the Indians of North America are a case in point; and the ritual of certain Australian clans who, in their ceremonies, mimic the life history of the witchetty grub, provide two widely separated instances of the attempt of Man to induce the cause by imitating the effect. A somewhat similar type of magical rite is performed by Australian aborigines who make an imitative totem to placate some powerful benefactor (*see* Colour Plate, facing p. 33).

The practices classed as imitative magic are well shown in the medieval doctrine of signatures, a primitive form of homoeopathy. The eyebright (*euphrasia*) was supposed to be good for eye affections, because the corolla of the flower resembled the human eye. Turmeric was administered in cases of jaundice, because it was yellow. These are two of many instances.

Contagious Magic. But there is another form of magic, closely connected with imitative magic, which is, for purposes of study, termed contagious magic. The reasoning is that possession of the part carries with it control of the whole, and this idea works two ways, beneficent and maleficent. It is just a question whether the individual can put himself in physical touch with such supernatural powers as he believes beneficent, or whether some enemy captures some physical attribute, even a lock of hair, upon which magic can be worked.

COMPELLING THE RAIN. *Among the Northern Australian aborigines an old man is chosen as principal 'rain-maker.' Here is one, with his two assistants, in his laboratory. His stones, troughs, pointing-sticks and other objects, are important items in his mystic processes.*

Photo, F. E. Williams

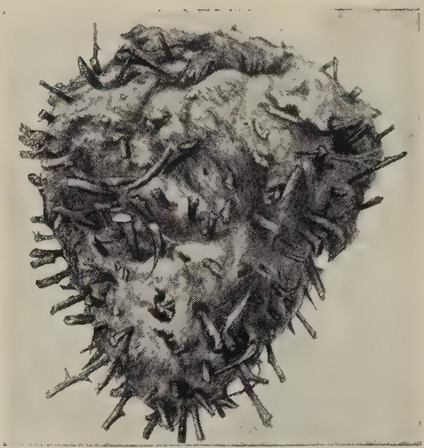
To take one instance of a world-wide belief, the chiefs of Hawaii possessed a private spittoon, which was emptied every night by a confidential adherent, below high-water mark, lest some enemy might obtain the material that had emanated from the body of the chief and so become possessed of power over him. Until quite recently it was—perhaps is—believed in certain parts of England, that hair combings should not be thrown out of the window, for fear that they might be intertwined by birds in their nests, when insufferable headaches would result until the nests were discovered and the hair extracted.

In this connexion the magic associated with personal names has its place. The personal name is as much a part of individual personality as a lock of hair. In the Mahomedan and Judaic religions it was believed that the knowledge of the personal names of Allah and Jehovah gave infinite powers over time and space.

In Egypt the legend of Isis, who wished to obtain the name of the great god Ra, provides an even better example. Collecting Ra's spittle (contagious magic), Isis made a serpent, which bit Ra. Ra, suffering pain, applied to Isis for healing, which she refused until he would reveal his true name. This he did, with the result that Isis obtained control over him.

The same idea still exists today as a survival amongst us. Kipling was quite right when, in his story of 'The Maltese Cat,' he envisaged a captain of a polo team who called on them by name, and so destroyed the team element and made the individuals nervous.

Death by Suggestion. In the history of human psychology the knowledge and use of a name imply a call on the personality. No better example can be given than the sympathetic magic employed by so many peoples for the destruction of personal adversaries. Hate, usually based on a sense of injustice, is universal. Not so long ago wax figures were made and named (that is the point), stuck with pins, or burned.



20TH-CENTURY WITCHCRAFT. *This calf's heart, studded with pins, thorns and twigs of witch-hazel, was found in a Dorsetshire cottage in 1902.*
Courtesy of Royal College of Surgeons

This operation was supposed to procure the demise of the hated person. The process, which might be termed telepathic death, often achieved its results by sheer suggestion; but in some societies, like those of West Africa, the victim could approach the fetish-man and by payment obtain the withdrawal of the nail driven into the image, which was supposed to call the attention of the supernatural powers to mortal delinquencies.

Related to the idea of contagious magic are the practices, almost world-wide, whereby man has attempted to obtain the help of supernatural powers by contact. In England there are many wishing wells, where the visitor throws in a pin and makes a mental wish. It has become a game, more or less; but the inception of the practice is very old. These wells, now associated with the names of Christian saints, were originally shrines of pagan deities. A pin, the least expensive article of dress, but nevertheless imbued, by contact, with the personality of the offerer, places the supplicant in direct communication with the supernatural power. It is the inception of some form of communion with the higher powers, and eventuates locally in cannibalism, actual or ceremonial.

Cannibalism—that is to say, the eating of human flesh—has more than one cause; but the idea is world-wide, and the strips of garments attached to trees around the monasteries of Tibet represent the desire of pilgrims to attain personal contact with holiness.

The relationship of magic and religion, briefly discussed in this lesson, is dealt with in most masterly fashion by Sir J. G. Frazer in 'The Golden Bough'—a book which cannot but be appreciated by every serious student of anthropology.

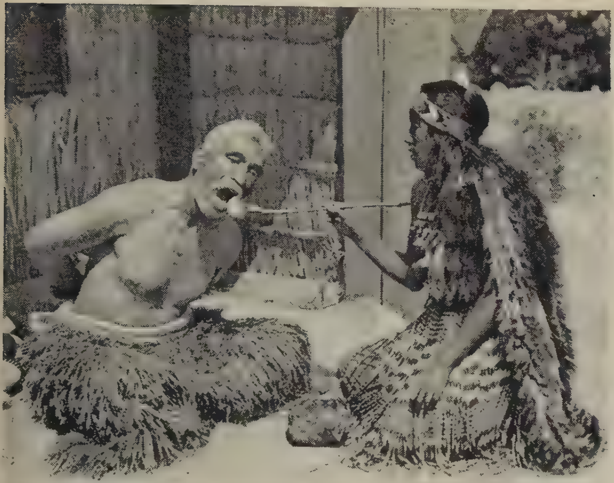
LESSON THREE

Tabu, Fetish and Talisman

POLYNESIAN in origin, the terms *mana* and *tabu* are used in anthropology as representing the obverse and reverse of a dominant power. Mana is a personal attribute, which waxes and wanes with the individual. It implies the compelling force, which can be inadequately described as personality, but better as virtue in the Biblical sense. In primitive society it is more especially associated with chiefs, but a chief who loses his mana meets a Napoleonic downfall. Tabu, on the other hand, is restrictive. It has its survival in the green and red lights which regulate traffic under modern conditions. It is generally imposed by individuals who have mana. In many primitive communities a tabu is imposed on the food plantations, in order to prevent premature collection by an improvident population. But tabu has a further extension, and in social anthropology extends to individuals.

A chief in New Zealand, for example, having great mana, and the right of imposing tabu, was also the victim of the tabu which attached to him personally. His person was sacred, and any object, such as a garment, which had been in contact with him was equally sacrosanct, and a commoner who inadvertently assumed a discarded cape or skirt of a chief died by pure suggestion when he became aware of the fact. The belief gave much trouble in the early days of colonization, because a chief often asked for a drink of water at the house of a white settler, but would immediately smash the glass, in order to remove the danger which would inevitably confront any subsequent user. The act was frequently misinterpreted, the host regarding it as an insult.

But there were occasions—for instance, when a chief was being tattooed—when his personal tabu was so exaggerated that he



UNDER TABU. *Rendered tabu by having touched a dead body, this old Maori was cut off from all contact with his fellows. He might not even touch food with his hands, lest he should spread contamination, and was fed by another person who avoided contact by means of a forked stick.*
Photo, Mondiale

became a danger to himself. He dared not touch his food; it was beneath his dignity to eat like a dog from the ground; he could not be touched, save by the professional tattooers; and so he was fed through a wooden funnel. Specimens of these instruments, beautifully carved, are to be seen in the great museums.

How Tabu Works. Tabu works in many ways, but there is one form which seems to be inherent in human nature, and that is the blood tabu. Among individuals of all races there is an extraordinary abhorrence of blood. Admittedly, blood sacrifice is widespread, but it is performed ritually by qualified practitioners, and as such is justified. But, apart from ritual, blood is a sacred thing, and so we find that amongst the Bushongo folk of the Kasai river, in the Belgian Congo, the judges who preside over murder cases vary in number, according as to whether the death has been caused by a sharp or a blunt instrument—really as to whether blood has been shed or not.

This question leads to the very heavy tabus laid on women, especially in the Pacific Islands. No woman dare step over a fishing net laid out to dry on the beach without incurring very severe penalty, because of the danger of scaring all the fish away. Most primitive tribes believe that women are definitely repugnant to food animals, especially in respect to the blood tabu, and the idea has been extended to such length that hunters must leave their wives for two or three nights before going into the bush or, in the case of Santo Domingo, before seeking gold.

Fetishes. The words fetish, amulet, and talisman are frequently misunderstood, but they have a definite meaning in anthropology. A fetish is an object which is supposed to enshrine a supernatural spirit that can be called to the aid of the individual possessor, just as Aladdin could call his djinn. But a fetish requires preparation. For instance, many wooden figures from Africa appear in the sale rooms as fetishes, but no carving is a fetish until the proper words have been said over it, and usually a

AFRICAN DIVINATION. *Holding in each hand an antelope horn fetish, tufted with monkey hair, a youthful sorceress of the Guere tribe of the Ivory Coast kneels in a state of rigid ecstasy.*
Wide World Photos

WITCH-DOCTOR'S JU-JU. *The objects stuck in the central part of this Nigerian fetish, between the eight human skulls, include four human thigh bones, a hand carved in wood, a knife, a dagger and an iron skewer.*

Courtesy of Royal College of Surgeons

magical compound (including blood) has been applied to it. The spirit is invoked by the word-charm and retained by the magical compound; there is no essential need for the human form and often the compound constitutes the fetish.

A fetish is both protective and offensive. It keeps the possessor from harm and it can be invoked to inflict hurt on an enemy. But here again the question of mana comes in. If a fetish loses its mana, in the sense that it ceases to be effective—judged, of course, by results—it is often punished, or finally discarded. The flogging of the figures of the Christian saints was not unknown in medieval times (even much more recently in backward countries), when they were believed to have been defaulters in the way of protection.

PROTECTIVE AMULETS. *Now regarded as purely decorative, horse brasses originated as talismans to avert evil or bring good luck. A full set numbered nineteen, of which the two horses above are wearing four each.*

Photo, V. S. Manley

Charms. Amulets and talismans, grouped under the general heading of charms, differ from fetishes in that their magical properties are not due to an indwelling spirit but to their form, material, colour, or inscribed patterns and words. The dividing line is so fine that they can hardly be treated apart; but, to speak generally, an amulet is passively protective, while a talisman is not only protective, but an active luck-bringer.

Amulets have their use today, especially in regard to the belief in the evil eye, a maleficent power which is supposed to be inherent in certain individuals. An amulet of a startling colour (such as coral), or fashioned in some obscene shape, was supposed to attract the evil gaze from the wearer of the charm. Many gestures used in southern Europe have their origin in this idea, but hardly any of the wearers of the amulets or the employers of the gestures know the origin of the practice or the real meaning of the amulets which they wear as jewelry.

The subject is too large to be treated in detail: two instances must suffice. In northern Africa, from Egypt to Morocco, the number five is regarded as protective against the evil influence. It is enough to say 'My five in your eye,' spreading out an outstretched hand. But nearly all of the Algerian and Moroccan jewelry is inlaid with stones which can be reckoned in series of fives. The amethyst stone, worn by so many of the clerics in the Middle Ages, was supposed to be a prophylactic against intoxication, as, indeed, its very name implies.

Though it may be said that the talisman is inherently an amulet, in so far as it is protective, the talisman is also active and ensures prosperity. The talisman is a mascot. The written charms, used by the Mahomedan peoples of Africa, are both amulets and talismans, because they include the names of Allah; here, again, is the magic of names. The terms used are really the wording of the classroom. The distinction between them is not made by primitive people.

LESSON FOUR

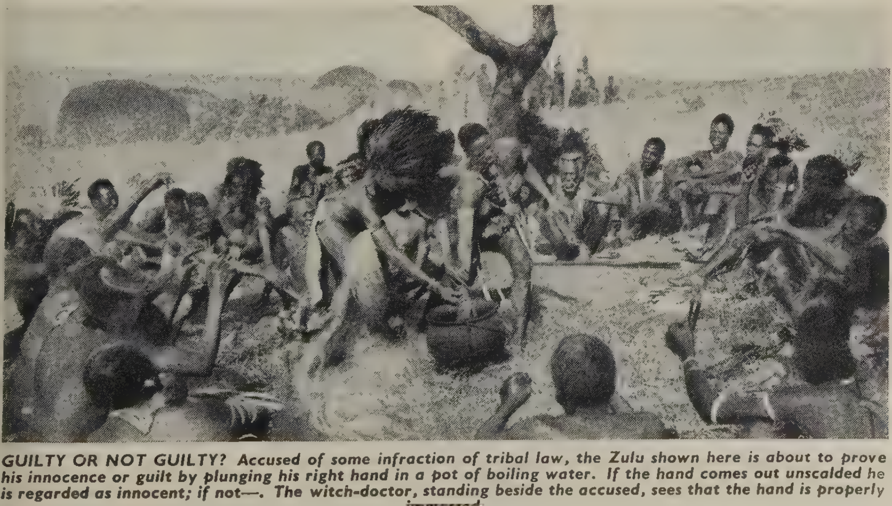
Dreams and Ordeals in Savage Magic

In his dealings with the mysterious influences which he attempts to control by magic, Man has constantly sought information from them in regard to the present and the future. As regards the present, the course taken is generally in the nature of police proceedings, to 'smell out' a thief, or to identify a practitioner of evil magic. Hence arises the practice of ordeals, which, in a sense, form the origins of the police methods known as the third degree. The idea can be illustrated from all over the world, and across many centuries of time, but one or two instances must suffice.

Detecting the Wrongdoer. Take, first, the method of identifying a malefactor common in Central Africa. A block of wood, moistened with the juices of certain herbs, is rubbed against another block, carved in the form of an animal. As the ceremonial movement proceeds, the names of individual members of the tribe are mentioned, and when eventually the friction is checked the person whose name is being pronounced is considered to be indicated as the delinquent.

In serious cases a decoction of poison may be administered, death being regarded as proof of guilt. The general principle of the ordeal survived in medieval times in Europe, sublimated, finally, into the ordeal by battle. Possibly the most grimly humorous ordeal was that in vogue amongst certain Eskimo tribes, when the accused was dropped into the sea some distance from land. If he drowned, his innocence was accepted; but if he swam to shore his guilt was proved and further means were taken to ensure his elimination.

Primitive Prognostications. But as regards the future, Man is afraid. He wants to know something, but not too much. Yet the urge for foreknowledge is insistent at the present day, and crystal-gazing, card-turning, palmistry and astrology are allied to the bone-throwing of African natives and the divination by maize grains practised by the early Peruvians. It would be barely possible to quote a single primitive tribe which had not some method of its own for diagnosing the future. Much of this prognostication is connected with the animal world, as the flight of a bird from the right or left in classical times, or the inspection of the entrails of a sacrifice. Later still, in our civilization, the word of fate is found in the Bible by slipping a paper-knife into the pages and reading the first verse which encounters the eye. These beliefs are classed in the



GUILTY OR NOT GUILTY? Accused of some infraction of tribal law, the Zulu shown here is about to prove his innocence or guilt by plunging his right hand in a pot of boiling water. If the hand comes out unscalded he is regarded as innocent; if not—. The witch-doctor, standing beside the accused, sees that the hand is properly immersed.

DIVINING THE FUTURE. In this photograph is seen a Liberian soothsayer examining coloured shells in a calabash to determine whether or not the native carriers may safely accompany the white man into the bush.

schoolroom as omens, and have their survival today—for instance, in the fairly prevalent belief that breaking a looking-glass portends seven years of ill-luck.

Interpretation of Dreams. From another point of view the question of dream-visions is important. Many primitive peoples, as far as evidence goes, do not differentiate clearly between the dream life and the waking life. Many peoples whom we call primitive take advice from dreams, and there are many moderns whose mental attitude to the day's work is conditioned by a particularly vivid dream. The study of dreams is only in its inception; but the works of Freud and Jung make out a very good case for the argument that the human mind works on the same principle, rejecting impulses which run counter to local sociological restrictions, but which, as it were, bubble up in sleep in a disguised form. The question is huge and only half explored, but mankind appears to dream on the same lines, and the dream life has a definite bearing on religion.

The interpretation of dreams is very ancient, and, apart from the dreams of an individual, which apply only to himself, the visions of the medicine-man in Asia, Africa, or America, often stimulated by some narcotic, have been known to affect the destiny of an individual, or even of a tribe.

Idea of the Soul. But sleep and the dream, as Tylor explained, brought an answer from primitive man. Sleep is the analogy of death. The body is comatose, in appearance dead, but there is a revival, and in the meantime the individual has been travelling far, having adventures, meeting dead relations, especially father and mother. So there is something in Man which is not all body, which leaves the body at night temporarily, but must return in order to keep the physical organism alive. For the present purpose let us use the word soul as applying generically to the incorporeal element in Man. This non-physical element is frequently subdivided amongst various peoples of the world, and the component elements are, again, ill-defined. He would be a bold man who would state exactly what he meant by soul, spirit, and intellect respectively. In investigating the beliefs of primitive peoples, particular caution is necessary, because the ideas of the individual are equally loose, and the difficulty of comprehension, especially through the lips of an interpreter, provides further complication.

Where the soul is considered as a single entity, its absence, during sleep, is regarded as normal. But should that absence be prolonged for any reason, sickness develops. Among the Indians of the north-west coast of America, one cause of sickness is believed to be this absence of the soul, and it is the task of the shaman, or medicine-man, to recapture the wandering soul, which he confines in a little walrus ivory tube and replaces in the body of the sufferer.

A similar practice prevails in Polynesia. In the island of Pukapuka, a string of loops, made of coconut fibre, was suspended from a tree, and the priest watched until a flying insect passed through one of the loops. This insect was the bearer of the errant soul, but the soul, becoming entangled in the loop, could be retrieved by the priest, and restored to the patient.

Here the soul is regarded as one entity, but in other instances dualism occurs. There is a dream soul, which can leave the body without harm and return again after its adventures, and a life soul, the absence of which results in physical death.

The body's shadow was considered an integral part of the soul. Hence the widespread belief that a corpse can cast no shadow. Perhaps the ancient Egyptians provide one of the best examples of subdivision of the soul. There was the *ka*, the double, corresponding to the dream soul, that after death inhabited the tomb; the *ba*, in the form of a human-headed bird, that spent its time between the underworld and visiting the tomb; the *khou*, a rather obscure element, which probably might be translated intellect; and the *khaibit*, the shadow.

LESSON FIVE

Human Sacrifice and Cannibalism

The idea of the soul, combined with experience that there are forces in Nature outside the direct control of humanity, has no doubt led to the conception of a divine soul, incarnate in a human body, which must be released and reincarnated when the body shows signs of deterioration from age.

Sir J. G. Frazer (in ' The Golden Bough ') has shown that in early Roman times the priest who presided over the sacred grove at Aricia, the ' priest who slew the slayer and shall himself be slain,' was regarded as the incarnation of a fertility spirit, who held office only so long as he could defend himself against other competitors. The divine right of kings and chiefs is a common idea, but many kings and chiefs only hold that right as long as they are physically fit. The Shilluk kings of the Upper Nile were regarded as divine, but at night they were unguarded and open to attack on the part of any pretender. Among certain West African tribes, when the chief showed signs of waning physical powers, he was presented with a gift of parrots' eggs as a hint of honourable suicide. If the hint was not taken, his ministers or his wives took the matter into their own hands.

Killing the Man-God. But one of the best examples of the divine soul incarnated is found among the Aztecs. In early Mexico a young man of perfect physique was chosen as representative of the god Tezcatlipoca, the Jupiter of the Mexican pantheon. For two years he lived in all the luxury which that semi-civilization could provide. He was treated as a god, his every wish was fulfilled, and four wives were allotted him. At the end of the two years he was escorted up the great pyramid, discarding his divine regalia as he proceeded, and was there sacrificed. A new youth was then chosen as the vehicle of the divine soul.

The basic idea in all these practices is the same. The presence of a divine element in a tribe, incarnate in the body of one of its individuals, is a guarantee of prosperity. But the divine influence cannot function with full effect unless the corporeal vehicle is in full physical condition. If the individual who contains the god deteriorates physically, then the luck of the tribe wanes. Crops fail; flocks and herds yield a lesser produce; sickness appears generally. So, on the first signs of loss of virility—or, in the case of Mexico, long before—the divine soul, protector and fertility power, is transferred to a more efficient body. Reverting to Lesson 3 (page 8), the mana of the god-on-earth cannot function satisfactorily except through a body in the prime of its health and vigour.

Religious Cannibalism. The custom of eating human flesh is closely connected, in the majority of cases, with the point of view represented above. The widespread idea illustrated by the practice of contagious magic leads to the further process of eating the god in order to acquire something of the divine qualities. Traces of this are to be found in more than one of the great religions which have won the allegiance of civilized men. On these lines the Aztecs ate small portions of their sacrifices, but the privilege was confined to the higher ranks and the procedure was ceremonial—a form of communion with the divine essence. The same idea occurred in New Zealand, where a warrior, having killed a noted fighter, would swallow his eyes, which were supposed to contain the soul, in order that by so doing he might reinforce his own physical prowess.

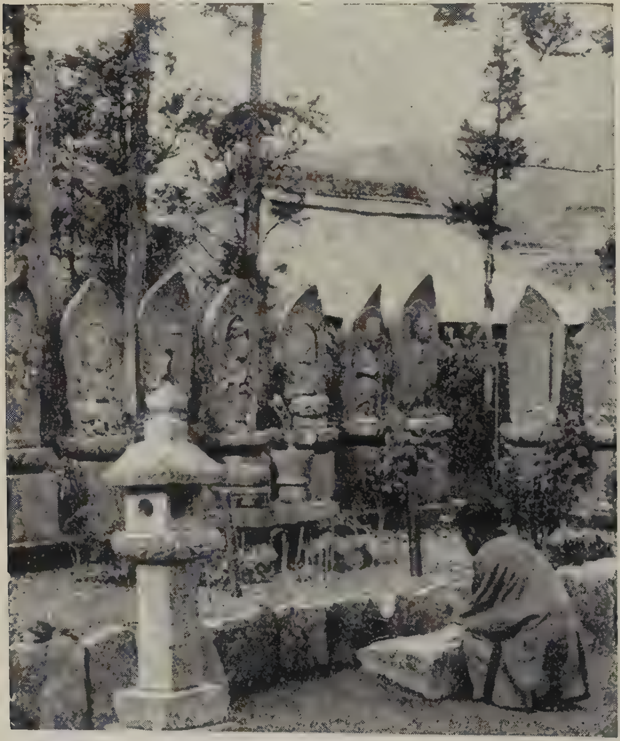
Cannibalism, when analysed, appears on the whole to be ceremonial, and based on the principle of absorbing the qualities of the deceased. But it is not entirely so; there are several other reasons for the practice. The most important is the lack of animal food, of which the Pacific islands provide a good example, although the ceremonial significance is difficult to disentangle from the craving for meat; and there was no mammalian meat, except that of the rat, in the Pacific before the introduction of the pig.

Revenge also plays a part. Cannibalism spread in Africa because, in inter-tribal wars, prisoners on one side were eaten as an insult, and the other side made a similar gesture. But in virtually all these instances the practice was confined to men. Women were excluded. Special pots were used and a different name was given to the cooked flesh. A good comparison is provided by our terms sheep and mutton.

So the instinct of revenge and imitation led to the spread of a practice which had a real meaning either as an insult or as a definite attempt to obtain the qualities of the deceased.

Pious Eating of the Dead. There is yet another form of cannibalism, a sympathetic aspect, as among some of the vanishing or vanished tribes of Australia. In this case the eating of the dead is a pious deed and a sign of respect. It is possible that the point of view may be confused, including an idea that the soul of the progenitor should be retained in the family; but there seems to be evidence that it is the duty of those left behind to preserve the physical body of the departed from corruption, and among the more primitive tribes the preservation of the spirits of ancestors, preferably incorporeal but closely connected with the body, has led to mummification, a practice also found in many other parts of the world.

The idea of sacrifice is, from one aspect, closely connected with the belief in the survival of the soul after the death of the body. It is obvious that a people which believes in supernatural powers wielding the forces of nature that Man cannot control will attempt to placate the most dangerous. The supernatural forces, personified or impersonal, are regarded with awe by the more primitive tribes, and generally receive more attention in proportion as their power is regarded as destructive. Many tribes recognize a creating god, but his work is done—he is benign, and not much notice need be taken of him. But the powers which can work ill and bring misfortune require



REVERENCE FOR THE DEAD. In many parts of the world—in China and Japan in particular—belief in the continued power of the dead to harm and to bless their descendants still persists. Here is depicted a Japanese peasant in an attitude of devotion before the graves of his ancestors.

recognition, and receive it in the way of sacrifice, offered either as a guarantee of favours to come or in placation of wrath incurred by some offence.

In many countries there is a dualism of good and evil influence, especially among peoples who have worked out a more or less organized pantheon. To take one example: throughout the tropical belt, amongst agricultural peoples, the rain-god is not only the god who fertilizes, but the god who smites, because tropical rain is nearly always accompanied by lightning. The idea extends beyond the tropics; the Greek Zeus, the Roman Jupiter, and the Indra of the Aryans in India—all benignant deities—were hurlers of thunderbolts.

Propitiating the Ancestral Shades. It is not only these divine powers which require attention, but also the souls of ancestors. In places where mankind has developed an organized social system, coupled with the belief of some form of survival of the soul after death, it is a natural consequence that these disembodied souls should take an interest in the affairs of the tribe. Fathers who have wielded authority over children still keep an eye on them; chiefs who have administered a tribe continue to exercise supervision. In their disembodied state they have powers transcending those which they enjoyed on earth, and can punish if appropriate attention is not paid to them. That attention mostly takes the form of sacrifice. Ashanti and Uganda provide two of the best examples of wholesale human sacrifice made on occasions in order to furnish the previous chiefs with a fresh retinue of retainers.

As a result of the added power of the disembodied soul in handling natural forces, in parts of West Africa a poor man, suffering under a sense of injustice, has not infrequently committed suicide in order, as a soul untrammelled by his earthly circumstances, to obtain the revenge on the rich man, his oppressor, which he could not achieve in his terrestrial life. Even the humbler members of a community where ancestral worship is practised (for instance, in China and Japan) make offerings to deceased members of the family. Such offerings constitute an appeal for help and a propitiation, but sentiment no doubt plays some part in such practices, and survives in the custom of placing flowers periodically on the resting-places of the dead.

LESSON SIX

Burial Customs

When the soul—or that element of the soul which is the life-element—has definitely departed from the body, the treatment of the physical remains varies considerably amongst different peoples, according to their particular mental attitude towards the released spirit and their belief concerning its future destiny. It is not unnatural that the immaterial souls of chiefs, heads of clans, fathers of families, who have held authority in this world, should be supposed to take a beneficent interest in the tribe, clan or family, or that they should be regarded with honour and more or less affection, even though they may need offerings to remind them to continue the protection of their descendants or people.

Propitiating the Spirits. Some peoples, however, think of their dead as malignant and resentful. Dr. W. H. R. Rivers held that, in regard to Melanesia, the method of disposal of the dead depended, to a very great extent, on the mental attitude of survivors towards the spirits of the departed. These required to be propitiated, lest they might take vengeance on the living. His theory can be supported by practices from all over the world, based on the idea that the life-soul hates to leave the body and lingers for a time, haunting the place of death. Among peoples who regard the disembodied soul as malignant, the destruction of the body is essential, and the readiest method is cremation. On the other hand, where the tribe or family wish to keep in touch with the kindly dead, then burial is the custom, and the most cherished possessions of the deceased are provided for their use in the other world.

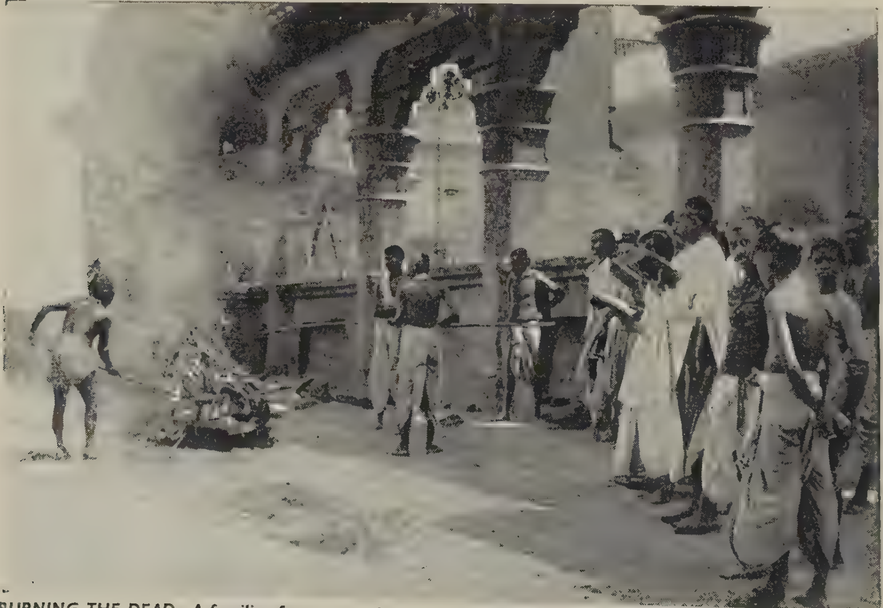
In arid regions, such as Egypt and Peru, means were taken to assist the process of Nature; embalming and mummification were practised. Professor Elliot Smith traced the custom of mummification in Egypt to the natural environment. Bodies buried in sand did not, normally, decay, and hence arose the idea that they should not decay, otherwise the *ka*, the dweller in the tomb, or the *ba*, the occasional visitant, would become extinct. The Egyptians, therefore, evolved a process which ensured the preservation of the body.

Under similar climatic conditions the Peruvians, both of the coast and the highlands, inspired by the same idea, took care of the desiccated bodies of their ancestors and, under the Inca regime, paraded and honoured with all ceremony the mummy-packs of previous rulers and heads of clans.

Rivers' theory does not hold good for the whole world, because cremation does not everywhere indicate fear of the dead. It was the custom amongst the Norse people to send the dead viking out to sea laid on a blazing pyre kindled on his ship. Burning of the dead in India likewise implied no hostility to the departed spirit.

Aztec Burial Rites. There are instances of dualism in funeral rites within the same community. Perhaps the best example is provided by the Aztecs of Mexico at the time of the Spanish conquest. These Aztecs had been in control of the Mexican valley only for a century. They were wandering hunters from the north, who by force of arms established themselves as rulers. But, being hunters, they had no agricultural god—that is to say, no rain-god—so they were forced to adopt the rain-god of the agricultural population of which they became the overlords. Warriors who died in battle, or on the stone of sacrifice, were cremated—a frequent habit of wandering tribes; but those who died by drowning, or of dropsical affections, were buried, being regarded as claimed by the rain-god of the earlier valley-dwellers. In either case the fate of the soul was equally happy.

Keeping the Ghosts Away. Another point of view which influences the disposal of the body refers to the quality of the soul. Individuals who have died by an abnormal process, such as suicide, were buried at crossroads in England, so that the malignant soul should be confused by the diverging paths and therefore be unable to find its way back again to haunt the village, and, further, that the evil influence should be dissipated by the continual passage of the living in various directions. Until 1823 suicides in England were buried with a stake through the body, that the ghost might not wander.



BURNING THE DEAD. A familiar feature on the Ganges, India's holiest river, is the ghat or flight of steps on which the Hindu dead are cremated. Of the burning ghats those of the sacred city of Benares are in most request, but that of Calcutta, here seen, is very popular. The body to be burnt is anointed with ghee and, after suitable prayers have been said, the next of kin sets fire to the pyre.

Photo, Ewing Galloway

***DESICCATED HUMANITY.** Among the Huambisa and Antipa Indians of the headwaters of the Amazon, in the Ecuador and Peru hinterland, mummification is still practised, as is evidenced by the human head, artificially shrunken to the size of a man's fist, shown on the left. In the right-hand photograph we see the embalmed bodies of an adult and child excavated at Assiut, Egypt, from rock tombs in which they had lain for about 3,000 years.*

Photos, Mondiale and Donald McLeish

In eastern Europe within the last century, graves of alleged vampires have been opened in order to check their evil activities by decapitation and sword thrust. A survival of the idea that the soul may be killed by destruction of the body may perhaps be seen in the practice of placing the bodies of executed criminals in quicklime.

Even in countries where the dead are regarded as beneficent protectors, the idea prevails that the soul should return to the other world, and not haunt the living unless invoked. So, in western and central Africa, the corpse is often taken out of the hut by a breach made in the back wall, instead of through the front door, in order that the soul may not know the way back. In parts of Russia an axe is laid at the door to keep out the ghost. In India thorn bushes are placed in the road to disguise the way, and in southern Nigeria food serves as a barrier on the paths leading to the village.

A very good instance of this point of view is recorded by Professor Malinowski in relation to the people of the Trobriand islands. Here the dead are not feared, but the departed souls try to cling to the village. They have to go elsewhere, especially as they await reincarnation; so there is an annual festival held in honour of the dead. This culminates in a concerted rush through the village, which is supposed to drive the souls to another island, whence they will return ultimately as children in the same tribe.

LESSON SEVEN

Primitive Ideas of the Soul's Survival

BELIEF either in reincarnation or in a continued existence in the spirit world is widespread, but not universal; it appears to be frequently due to man's clinging to personality, and consequent desire for individual immortality.

Pictures of Paradise. Sometimes the dead are believed to return to this world in a new body, and perhaps in another form, as animals or even trees and plants; the after-life is also conceived as being lived in a land beyond mortal ken. This may be a materialistic paradise, such as the old Scandinavian conception of Valhalla, where dead warriors spent their time in a never-ending feast, drinking mead and—according to one story—eating the roasted flesh of the boar, which was always magically renewed however much was consumed. A similar conception is that of the 'happy hunting ground' of the aboriginal North American Indian's underworld, where herds of buffalo were chased with conspicuous success.

Amongst more highly organized American native races, belief in a paradise is frequent. For instance, in ancient Mexico the Aztec thought that men who died the death of a warrior—either in battle or upon the sacri-

***THROUGH SACRIFICE TO THE AZTEC PARADISE.** In Aztec Mexico human hearts were regarded as necessary for the sustenance of the gods. Here in this gruesome picture we see a priest kneeling on a victim stretched on the sacrificial stone, tearing out his heart through a gash in the breast made with an obsidian knife. It was believed that those who died in this way went straight to the paradise of the Sun, which was located in the east.*

British Museum, Zouche Codex

ficial stone—went directly to the paradise of the Sun in the east. Here they greeted the rising deity every morning by beating their shields with war-clubs, and formed his escort until he reached the zenith. At this point they left him and descended to earth in the form of butterflies, returning to the eastern paradise to salute the succeeding dawn. Meanwhile, the escort of the Sun was assumed by the souls of women who had died in childbirth, for this was accounted a warrior's death; when these souls had conducted the Sun to the point of setting, they returned to the earth in the form of moths.

Another paradise of the Aztec was also situated in the east, presided over by the old rain-god Tlaloc, who received the souls of persons who died of drowning or dropsical affections. Far inferior was the gloomy abode, Mictlan, a kind of murky Hades, presided over by the Aztec death-god, and inhabited by the souls of men and women who had no claim to other paradises.

There is a widespread idea that the kind of life lived by the deceased, and perhaps particularly the manner of his death, affects his after-death status. A modified concept of purgatory, or rather of degrees of happiness in the after-world, occurs not infrequently; while not only have many peoples no concept of a hell, but, as in the case of the Cuna folk of Panama, insistence by well-meaning missionaries upon such a punitive state in the land of the dead has occasioned serious objections to the acceptance of Christianity. It is, indeed, only amongst such highly organized religions as Islam, Christianity and Tibetan Buddhism, that we find a belief in a definite hell, or place of torment where punishment is inflicted, sometimes eternally, for sins committed in this world.

Destination of the Soul. The point of view of different peoples as regards the ultimate destination of the life-soul is almost as varied as mortuary customs. Amongst the primitive pastoral tribes of East Africa the ordinary man possesses no soul; his dead body is simply thrown out to the scavengers of the night, and his name is forgotten. Only chiefs and headmen are buried; and offerings are made at their graves in the hope that they will continue to protect and advise the clan as in life-time. In the rest of Africa, towards the north and particularly in the west, the other world is conceived as, more or less, a replica of the present, though more agreeable.

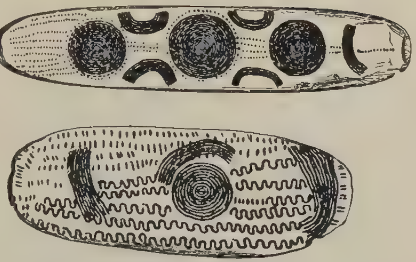
Primitive races, almost universally, think that the soul of the dead is desirous of returning to earth, an idea that is in complete contrast with that of the exponents of such complex and sophisticated religions as that of the Buddhists. To the latter, this world is a place of tribulation, and the most supreme happiness is the privilege, accorded only to the most worthy, of absorption into 'nothingness'; it is a signal of lack of grace when a soul is obliged to return to this earth under different animal forms.

The African primitive folk have no such idea of the world-weariness of the life-soul; according to their beliefs, this soul seeks re-entry into its old surroundings, and it is often thought that the first child born after the death of an important elder of the clan is imbued with the soul of the recently deceased. If more than one elder has died, objects belonging to each of them are placed near the baby, and the first to be touched by him is an indication of the particular soul informing the child.

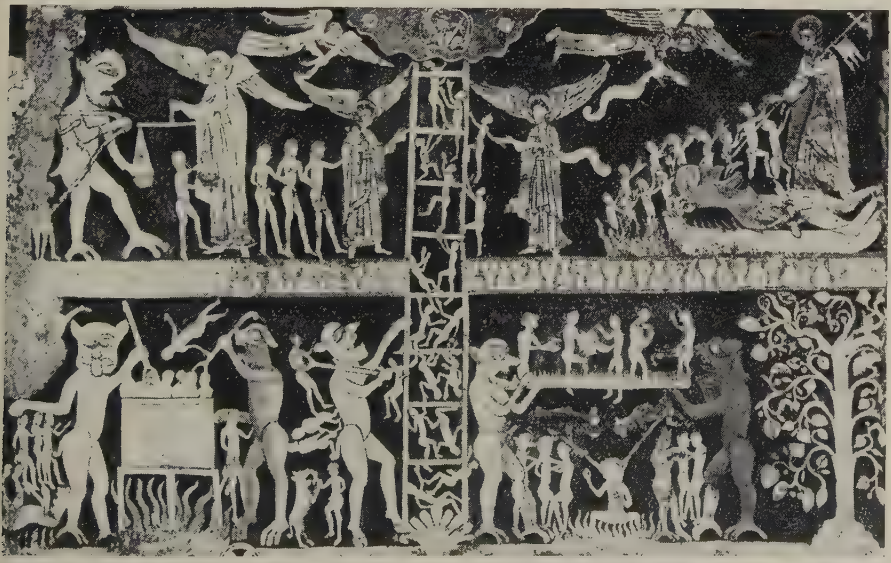
In many European countries customs survive illustrating the Early Christian belief that on All Soul's Eve the dead return to their former homes for a brief reunion with the living. Candles are lighted to guide and comfort the wandering souls, fires are kept burning and supper is spread. Peasants in the Vosges mountains also uncover beds and open doors and windows to emphasize their invitation. 'Soul cakes' are prepared and those who eat them repeat prayers for the welfare of the dead.

Old Souls in New Bodies. Amongst certain of the more primitive tribes of Melanesia and Australia, reincarnation is held to be the normal method of generation. Thus the inhabitants of the island of Kiriwina, in the Trobriands, do not associate connubial contact with conception; such contact is supposed to have some effect in preparing a woman for bearing a child, but is not a direct cause. They believe that women conceive whilst bathing in the sea, for souls (*baloma*) which have been driven away come swimming under water from the spirit island nearby, looking for a prospective mother. It is, therefore, no disgrace for an unmarried girl to bear a child, although usually the younger girls keep to shallower water when bathing in order to avoid impregnation.

Amongst the Arunta of Australia, too, the part played by the husband in the procreation of children is entirely unrecognized. Ancestral spirits are supposed to be closely attached to the carved ceremonial stones known as *churinga*, and although these stones, when not actually employed in ceremonies, are carefully hidden in the bush, any woman passing near the place of concealment is likely to be entered by one of these ancestral souls, and will thus, so it is believed, become the mother of a child.



CHURINGA. Among the aborigines of Central Australia, the Arunta in particular, the spirit of each individual is believed to be intimately associated with a churinga—a flattened slab of wood or stone, usually adorned with totemic carvings. When a child is born the kuruna or spirit is supposed to leave the churinga and enter the child, returning to it on the latter's death.



MEDIEVAL CONCEPTION OF HELL. This 12th-century wall-painting in Chaldon Church, Surrey, represents ' The Ladder of the Soul's Salvation.' In the centre will be seen a ladder leading from hell to heaven, marked by a vision of God set in a circle at the top. In the upper left-hand portion St. Michael is weighing souls while Satan endeavours to depress the scale. Below, two demons are busily stirring souls in a great cauldron, while another with a pitch-fork picks off souls from the ladder as they try to escape upwards. In the left-hand corner another demon is biting the feet of three little figures, supposed to be girls who were too fond of dancing, and a dog is biting the hand of a woman who gave to the dogs what she should have given to the poor. In the lower right-hand portion two demons are compelling souls to traverse a bridge of spikes; beneath, surrounded by flames and money bags, sits a usurer, gold coins pouring from his mouth. Above is shown the ' harrowing of hell ' by Christ, assisted by two angels. Such ' doom pictures ' as this were much in favour during the Middle Ages when few of the common multitude could read.

LESSON EIGHT

Kin and Kinship

The system of relationship by which human society is knit together is known as lineage, and communities are termed patrilineal or matrilineal according to whether descent is reckoned through the male or the female. It is not easy for one accustomed to the great patrilineal organizations of northern Europe to realize at once the full effects of the matrilineal system, which is, or was, the more widely spread of the two methods of reckoning descent among primitive folk.

Exogamy and Endogamy. As a rule, in primitive communities there are two definite groups known as *phratries*; the members of one group may not marry amongst themselves, but must choose partners from the other phratry. Sometimes, as in Australia, these phratries are subdivided into classes, the members of which may marry only amongst themselves. Groups whose members are not permitted to intermarry are usually termed *exogamous*, while those to whom intermarriage is allowed are known as *endogamous*. In Melanesia and Australia the various groups, phratries, or classes are frequently supposed to have a mystical connexion with a particular class of animal, plant or object—such as the eagle-hawk, bee, lizard, wallaby, whip-snake, or gidya tree—which constitutes, in a sense, a crest in primitive heraldry; there is also esoteric connexion between this *totem* and the human groups, for while the human being may sometimes hunt an animal of his totem's class, he will never eat it, and he relies upon every individual eagle-hawk, lizard, or whatever his totem may be, for protection and aid in time of trouble.

Tracing the Descent. If the community be patrilineal there is practically no difference between our method of tracing lineage and that of more primitive peoples, but it may be noted that, whereas our own civilized society is singularly deficient in terms denoting kinship, primitive man frequently uses a greater number of terms precisely defining relationships. We have such vague and unsatisfactory words as uncle and aunt, which do not indicate whether the person mentioned is father's or mother's brother, or father's or mother's sister; while, in English, the word cousin is even more hazy, since it does not even indicate sex. The Melanesian native in contrast uses carefully differentiated terms for all varieties of kinship.

Under the patrilineal system, as with us, children inherit the rank, property, and clan or phratry of the father, and look to him as their chief protector and representative. But under the matrilineal system the difference is almost startling, for the children inherit the mother's phratry or clan, and have nothing to do with that of the father. In these circumstances, a young man's leader and natural protector is his mother's brother, since he is the nearest male relative of the phratry to which the youth belongs. The intricacy of this relationship amongst many primitive tribes is shown by the many obligations which a sister's son and mother's brother mutually admit. Incidentally, throughout the greater part of Melanesia a young man is justified in regarding the daughter of his maternal uncle as his predestined bride; she fulfils the necessary condition of belonging to a different phratry. And so generally accepted is the right of a youth to his mother's brother's daughter that in case of her marriage to another person he is able, amongst many tribes, to claim heavy compensation. He could not, however, marry his mother's sister's daughter, since she would belong to his phratry.

Australian Marriage. Some of the most primitive tribes of Australia have developed a much more complicated system, with phratries divided into four or even eight classes, marriage between these groups being strictly controlled by rule. The system is best illustrated by the accompanying equations from 'Kinship and Marriage in Australia,' by N. W. Thomas:

$$\frac{A1}{B1} = A4 \qquad \frac{B1}{A1} = B3$$

$$\frac{A2}{B2} = A3 \qquad \frac{B2}{A2} = B4$$

$$\frac{A3}{B3} = A2 \qquad \frac{B3}{A3} = B1$$

$$\frac{A4}{B4} = A1 \qquad \frac{B4}{A4} = B2$$

In each case, says Thomas, the male is the numerator, the female the denominator, and

WHERE WOMAN RULES. *An example of the matriarchate in the world of today is afforded by the Pueblo Indians, sedentary agriculturists who have their homes in the south-western United States. The range of structures seen in this photograph, with its square rooms, flat roof and storeys arranged one above the other in terrace fashion, constitutes a community house, belonging to and controlled by a woman of the clan. When the owner of such a house dies it becomes the property of her eldest daughter. The beehive-shaped objects in the foreground are ovens.*

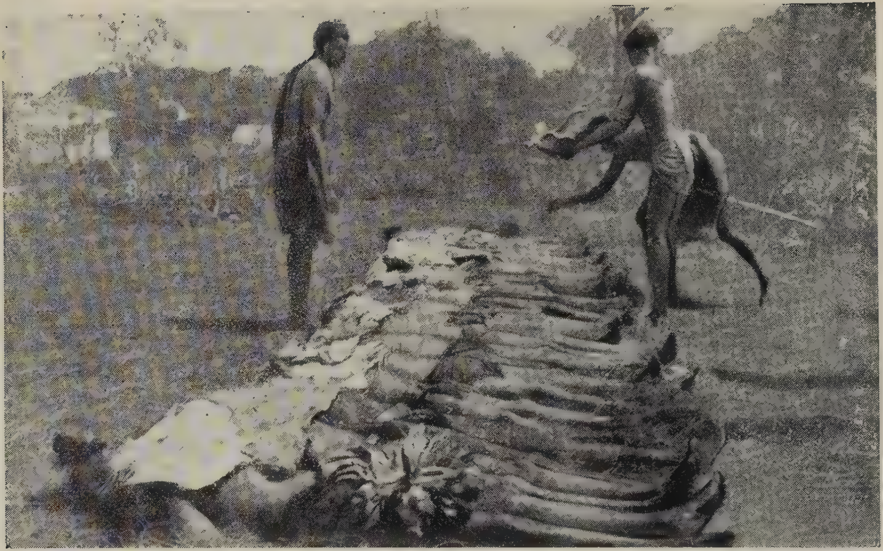
Photo, E.N.A.

the '=' shows the child. Thus, an A1 man must marry a B1 woman (no other bride is allowed); the child belongs to the 4th class of A phratry, and is obliged to consort with a person of the 4th class of B phratry. The status of the children of this union may be either A1 or B2, as the equation in the preceding page shows, according to whether A4 is the male or female.

Matrilineal organization enhances, frequently, the position of a woman in the tribe, especially in cases where, as in Indonesia and amongst the Pueblo Indians of the south-west of the United States, the husband goes to live with his wife's family. But for the most part women do not assume the rank, or exercise authority over the property, of which they are the conveyers. Rank is held by them for their children, but is exercised by brothers or husband; for example, in Queen Charlotte Island, off north-western Canada, where strong matrilineal tendencies prevail, a man when he marries will receive from his parents-in-law certain ceremonial privileges which he holds and exercises on behalf of the male children borne by his wife.

Importance of Rank. Amongst many African tribes rank is conveyed by the woman, and brother inherits from brother until the last son of the female transmitting the rank is dead; the rank then passes to the eldest son of her eldest daughter; thus the son of a chief has, in native eyes, no right whatever to chieftainship. This fact has more than once led to misunderstandings with white men in positions of authority, who have supported a pretender on the ground that he was the son of his father. The short history of the Aztec rulers of Mexico clearly indicates that a similar matrilineal system prevailed; and it is evident that these invading tribes from the north married, when they could, ladies of the ruling Toltec houses in order to obtain for themselves legitimate claims to authority. The same idea appears to lie at the root of the system of marriages between brother and sister practised by the royal dynasties of Egypt and by the Inca of Peru.

Although the matrilineal system appears to have been the earlier and more widely spread of the two systems of social organization, we find several instances of change to the patrilineal; none occurs of alteration from the patrilineal to matrilineal. The change seems, usually, to begin with the natural desire of a man that his wife's children should have some share in his property. So, among certain West African tribes, where rank still follows the female line, a man's own personal equipment, such as weapons



ARTIFICIAL KINSHIP. Youths who undergo together the rite of initiation into the state of manhood are henceforth bound together by ties of common suffering and exaltation. Sometimes the initiatory process constitutes a very severe test of the powers of endurance, as may be seen from this picture of aborigine youths of Arnhem Land, in North Australia, lying flat on their backs in the broiling sun while bull ants and other noxious insects are strewn over them. Their faces are covered with bark to protect the eyes.

Photo, Francis Birtles

which he has fabricated, is allowed to become the property of his sons after his death. The process of change is exemplified in the region of the north-west coast of America. In Queen Charlotte Island and in Alaska the matrilineal system is still firmly established; farther south, in northern Vancouver, it is breaking down so far as a man's personal property is concerned; still farther south, the social system has become almost entirely patrilineal.

Initiation of Adolescents. Apart from bonds based on kinship there are other strong ties existing amongst communities of all grades of culture. Adolescents, in many regions, are obliged to undergo certain tests, often preceded by a more or less exacting training, before they are recognized as adults and marriageable. These tests for youths are particularly severe amongst hunting tribes, such as those of the North American plains and of Australia; while in many African communities both boys and girls are obliged to undergo a long period of training or initiation, during which they are segregated in camps in the bush and instructed in tribal lore on all matters relating to sexual and social life. This training usually culminates in elaborate initiation ceremonies, and circumcision is performed, an analogous operation being inflicted on the girls.

Henceforth the young folk are regarded as men and women. Between those who have undergone training and initiation at the same time there is a bond approximating to that of brotherhood or sisterhood, and quite as firm. Initiation ceremonies of a similar character are widely practised in New Guinea and Melanesia. All fellow-initiates are here, as in Africa, linked by a tie practically as close as that of actual kinship.

Among certain American Indian tribes a girl must carry out rigorous ceremonies of purification, bathing ceaselessly, living upon ceremonial food and wearing cloth made of the inner bark of the maple, which was supposed to confer peculiar sanctity. She must not touch her hair or face, or these would decay. Among the Hupa Indians of California she must be 'danced over' by the men and women of the tribe for nine nights, at the conclusion of which she whips herself with strands of maple bark, gazing into polished abalone shells held by the women, to catch a glimpse of the supernatural world. After a final bath she is a free woman.

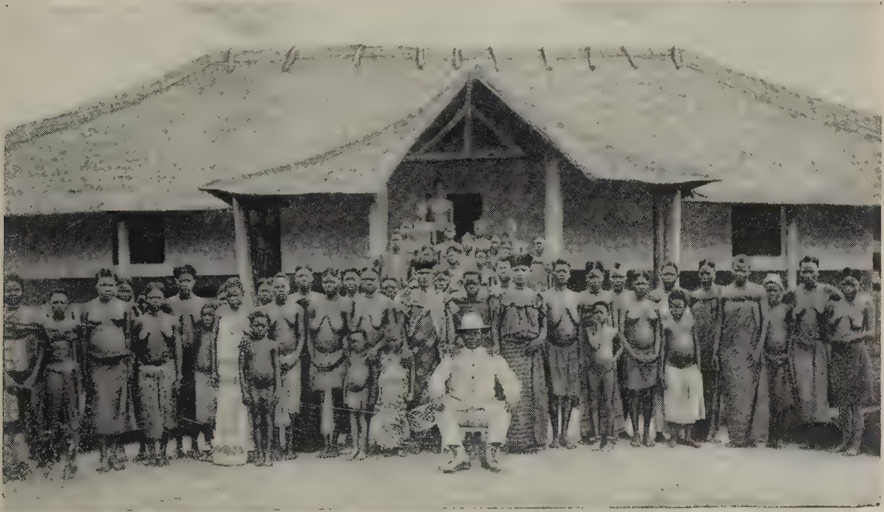
LESSON NINE

Marriage and Marriage Rites

MARRIAGE, wrote Prof. Edward Westermarck, the Finnish scientist, who was professor of Sociology in the University of London from 1907 to 1930, and one of the most distinguished of our social anthropologists, 'is not a mere sex relation, but an economic institution as well,' and this fact lies at the root of a myriad customs relating to the married state all over the world. Many ideas frequently regarded by western Europeans as curious, shameful or cruel have their origin in strict common sense, applicable to particular geographical regions. Monogamy is suitable to the economic conditions of a large part of the world, and tends to increase; but where polygamy, polyandry, or even group-marriage, are customary, logical reasons are to be sought. The free choice of two young people is generally accepted by ourselves as the ideal beginning of the married state; but 'marriage by purchase' and the choice of spouses by elder folk, are often based upon sound customs developed from special environments.

It has been suggested by some writers that promiscuous sex connexions between men and women preceded, among prehistoric folk, the condition called marriage, by which we mean, in the broadest sense, a recognized relation between a man and woman, most frequently, but not always, defined by a ceremony, and frequently, but not always, permanent. The maintenance of a common home for the man, wife, and their children is also usual. But occasionally these rules do not apply: amongst the Eskimo there is no ceremony; the woman is simply taken to the hut of the man, and, while monogamy is usual, a man may have two wives if he can support them by his hunting skill; many other American and many Australian folk lack a wedding ceremony.

Tendency to Monogamy. As to permanence, many primitive tribes, especially in Africa, follow strict regulations governing divorce; and in regions where 'mother-right,' the matrilineal system, prevails, the husband often makes no home for his wife and children. He may, in some cases, live with his wife's family; or, as with certain hill tribes of Sumatra, husband and wife continue to live with their own families respectively, and although the couple are



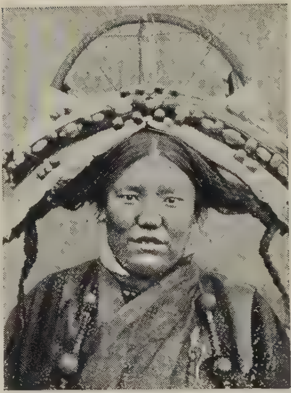
POLYGAMY ON THE CONGO. This African chief, whose dress and dwelling bespeak his admiration for European ways, possessed more than a hundred wives, some of whom are shown here. The two principal wives, of blood royal, are in European dress immediately behind their husband's chair.
Photo, Mrs. J. H. Harris

faithful to each other and divorce is unknown, the husband never supports his wife or children, only seeing them during visits. Similar conditions have been observed among tribes in West Africa, Abyssinia, New Guinea and New Britain, in the South Seas. Yet these can almost be said to be exceptions proving the rule that a strong human instinct (and animal instinct as well) tends to the choice of one mate by the male, and the creation of a home for this mate and the offspring of the union.

This deep-rooted idea is exemplified by primitive (patrilineal) hunting tribes of North America. Here, as in many other regions, polygamy occurred when a hunter was wealthy enough to keep more than one family—and the system was, as in many parts of the Orient, welcomed by wives, who thus shared the labour of the home; but it was considered anti-social for a man to take more women than he could provide with food.

In many parts of Africa where the patrilineal system is in force, the man is the maker, supporter and ruler of the home, and marries more than one wife when economic circumstances permit. Plural marriage in this and other tropical localities where children are fed by the mother until they are three years old or more, is a matter of convenience both to wives and husbands; the mother remains in her own hut with her child, in a privileged position; the other wife or wives alone receive the visits of the husband, and perform the chief labour of the household and the lighter field work assigned to women. The first wife in most polygamous primitive communities—and always in regions where Mahomedanism prevails—is the head of the feminine household. Complaints in such communities occur chiefly when young men are unable to find wives, because older and wealthier rivals carry off all the attractive young women for themselves.

Plurality of Husbands. Polyandry, the relation between one woman and a number of husbands (who are usually brothers), exists notably in Central Asia. It is a curious exception to normal sex relations, and seems to have arisen from an unexplained scarcity of women among a few Tibetan hill tribes. Here the woman rules, assigning tasks to her husbands, giving her favours as she prefers, and receiving support for her children from all. No ill-feeling seems to exist.



***BADGE OF POLYANDRY.** In Tibet, where polyandry has long been an established custom among some of the hill tribes, the woman who has more than one husband wears this distinctive head-dress, made of wool and cane and decorated with turquoise and coral.*

Photo, Mondiale

It is commonly remarked that, while many creatures have definite pairing seasons, Man seeks his mate in all seasons. But in primitive communities there is a tendency for after-harvest feasting and marriages to correspond. Agricultural work is over; food is plentiful, the thoughts of young folk turn from hard tasks to rejoicings. Thus in Papua, Assam, New Guinea, the hill country of India, and certain African regions, feast and sex-life bear a definite relation, as is proved by the incidence of births.

Importance of Female Fertility. Female fertility is often the *sine quâ non* in patrilineal society. Marriage is rooted in the family, and, therefore, neither a ceremony nor a mutual home is considered until a child has been borne by the woman, or, at least, until she is known to be pregnant. This custom is found in Formosa, among primitive Canadian tribes, certain native folk of Brazil, Paraguay, and other parts of South America as far south as Tierra del Fuego, and in many African regions. Where ‘ marriage by purchase ’ is the rule, a girl is sometimes neither paid for nor taken from her father’s house until she is about to become, or has become, a mother. Paternal pride is not necessarily always involved; the question of economics is frequently concerned; for children are needed in pastoral and agricultural communities, and in some regions a woman who has already borne a child is more eagerly sought as a wife than a virgin.

Artificial Defloration. The virginity of a bride is, indeed, for other reasons than the material one of preference for proof of fertility, not regarded as essential or even desirable by some primitive folk. Marked divergence of custom and opinion divides tribes geographically near; for while some tribes are careful of the virtue of the young girls, and a woman is regarded as unmarriageable if she is not a virgin, in others a girl is always 'deflowered,' occasionally by artificial means, before she is regarded as prepared for marriage.

The operation is sometimes—as in North Africa, Australia, and among certain native American folk—performed by the bridegroom. Amongst some Polynesians it is made a public occasion, the father of the girl performing the operation and displaying the proof of virginity to the assembled clan. Many tribes, with exemplars in tropical America, regard the act of defloration with superstition—it is unlucky; and responsibility, therefore, devolves upon the chief medicine-man, frequently the head of the tribal group, because he is the main possessor of mana. In some regions deflowering is performed during childhood, by elderly women; and it is considered disgraceful to leave the operation until puberty. In others, it must be immediately followed by sexual intercourse, again for superstitious reasons. The feeling of fear attached to defloration of a maiden is so widespread, even in Europe, that writers have connected with it the origin of the *droit de seigneur*, seeing the custom thus as a responsibility shelved by, and not a privilege lost to, the bridegroom.

Child Marriage. Child marriage, or, more usually, child betrothal, is common in regions far apart, as in the Americas, in islands of the Pacific, in India, both in the hills and lowlands, in Africa and Australia. Frequently babies are promised to each other in order to cement useful alliances between families; a binding betrothal also prevents a wrong choice on the part of a girl, and ensures her marriage at puberty. In tropical countries, where girls are ripe for marriage when but 10 to 12 years old, parents necessarily arrange weddings at an early age, and it is true of many primitive folk that there are no unmarried girls, and that prostitution is extremely rare—in some regions, unknown.

As a rule, the rites and ceremonies attending marriage among primitive peoples have no connexion with religion; they are civil and social customs, and the great majority have as their object the happiness and prosperity of the couple, the fertility of the union, and the health of the offspring. Amongst many tribes, perhaps especially in South America, the chief of the clan, who is often head medicine-man also, performs some slight ceremony; but this seems to be because a marriage affects the community, and the carrying out of a public rite differentiates a regular from an illicit union.

Wedding Tokens. The idea that marriage is, or should be, an indissoluble union is shown symbolically by the use of rings or girdles, or the joining of the wedding garments of the two persons concerned. Ceremonial hand-joining is common. Amongst the ancient Aztec people and in South India the clothes of the pair were ceremonially knotted; in other parts of Mexico the hands were tied together. Certain Chinese folk tied the hair of the bride and groom; in Assam the thumbs of the couple were fastened with a special kind of grass. The breaking of a coin (of circular shape) and retention

CHILD MARRIAGE IN INDIA. Here we see a child bride in the Madras presidency sharing her wedding meal with her tall bridegroom on her left; on her right hand is her little brother, who has just been married to the small girl standing behind him. This photograph was taken just before the Child Marriage Restraint Act—prohibiting the marriage of males under the age of 18 and females under 14—came into force in April, 1930.

of half by each of the couple has great magic in some regions; in others (as some parts of India) small wounds are made ritually in the bodies of bride and groom, and the blood mingled; or, again, the two are anointed with the blood of a special animal.

Occult and sinister influences are always at work to thwart the happiness and prosperity of the couple, and must be counteracted by magical aids. So that the bridegroom shall be aided in the consummation of the marriage, sympathetic magic is invoked in Africa, Java and Persia by the breaking of eggs. Sometimes a red thread is ritually fastened across the door of the nuptial chamber, and if the bridegroom breaks it easily all will be well. The use of red ribbons, or red pieces of cloth, during the ceremony are also part of symbolism connected with the marriage of a virgin. All over the world, grains are thrown, given or eaten as symbols of fertility, whether wheat, barley, rice or millet; or, as in some parts of China, nuts and such prolific fruit as dates are placed on the posts of the nuptial bed. Modern paper confetti, used at weddings nowadays, seems to be the symbol of a symbol.

WEDDING RICE-THROWING. *The widespread practice of scattering rice over bride and bridegroom was originally intended to symbolize wished-for fertility and to propitiate evil spirits. The substitution of paper confetti for rice robs the custom of its meaning.*

The Bride's Veil. The veil covering the head of a bride or the protection of a canopy or bower originated in the desire to shield her from the evil eye; crossed swords or knives also ward off malice. Danger for the bride lurks especially in the floor or soil of the new home, and doorways are favourite haunting places for evil spirits; hence the custom of carrying a bride over the threshold, and of putting down a special carpet for a wedding. Sometimes, if she walks into her new home, she wears someone else's shoes; and in some lands, in order to trick malignant spirits, both she and the bridegroom wear disguises, so that their sex is not apparent.

Delay in Consummation. Fasting and continence before marriage are also considered advisable in several parts of the world; and the consummation of a marriage is often delayed, for anything from a day or two to several weeks or even months, sometimes to avert the jealousy of demons, and sometimes with the practical object of allaying timidity or inculcating habits of continence. The couple may occupy the same room or even the same couch, but where ceremonial abstention is the rule, a young child or elderly relatives may be present during the prescribed period. This idea is widespread, from the New Hebrides to Borneo, from the Japan Sea to Assam, from Yugoslavia to Siberia and Mexico.

MARRIAGE BY PURCHASE. *In this photograph we see a young Zulu brave bringing his bridal gift of cattle to his future father-in-law just before the wedding. The animals are held in trust for the bride in case she should be made a widow, or to compensate her relatives should she run away.*

Photo, E.N.A.

Gifts to the Bride. Complicated and definite ritual in marriage is generally found in the Orient; in the New World the ceremony was, and is, usually more simple and less symbolical. Frequently, among South American tribes, the suitor offers to the girl of his choice a present of game from a hunting expedition, fruit from his plantation, or fuel for her father's fire; acceptance of the gift completes the ceremonies prior to marriage. But among many of these folk, where every girl is married at or soon after puberty, the young husband is, as a matter of fact, sought for by the parents of the maiden, and the match is already made before his ritual offering is brought. South of Panama, too, examples are found among matrilineal tribes of services being performed, as part of the marriage bargain, by the son-in-law for his wife's parents; in other regions he gives them such useful presents, according to locality, as animals, furs, implements, weapons, trade-cloth, shells, or ivory.

Since a woman and her children form an asset in many communities, we find instances where the husband not only offers gifts when he takes his bride but 'pays for' children when born. In connexion with the vexed question of 'marriage by purchase,' it may be mentioned here that the money, cattle or other goods handed over by a bridegroom to his wife's relatives is often not so much payment as a guarantee-fund. This is certainly true in Africa, where, if the wife runs away on account of the husband's proved ill-treatment, her relatives keep the goods; but if she is to blame for domestic trouble, the husband can demand his money or merchandise to be returned. The relatives of a wife are therefore interested in urging her to behave well.

Marriage by capture was formerly, especially among people following exogamous customs, almost the only way in which men could get wives. Other tribes were thus raided customarily in certain African regions, and since in many other peoples are found ritual survivals of a fight—sham battles are still part of the marriage ceremony in Morocco, Tahiti, Fiji and parts of Malaya—

MARRIAGE BY CAPTURE. Among the various ceremonies that are performed on the occasion of a Zulu wedding one of the most striking is the enacting of the attempted rescue of the bride, who, according to old tradition, is supposed to have been stolen from her people by the bridegroom. The bridesmaids, acting together in accordance with a preconcerted plan, make a determined rush as if to free the bride from her captor. In this united effort the bride, too, takes part, in order to make it clear that she herself has joined in this dash for freedom. This strange episode in the nuptial ceremonies of the Zulus, like so many similar features in the marriage customs of other peoples, is a survival of the generally obsolete marriage by capture.

Associated Press (*Carl von Hoffman*)

it appears that it was formerly usual in lands situated far apart.

Many marriage customs are not only lost in the mists of time, but not infrequently have been imperfectly understood by foreign observers; so that care has to be exercised in assigning origins to curious rites. It is, for instance, only of recent years that the interesting custom of the Santals, by which bride and groom are ritually married not to each other, but, respectively, to two different fruit-bearing trees, has been explained. This is not done, as formerly believed, in order to deceive the demons jealous of young couples, but as a method of placating, and bringing into close relation with the family, the ancestral souls believed to be resting in the tree-tops.

Wedding Feasts. Feasting, as between bride and groom, or with relatives of each party to the union, is sometimes not only an essential of the ceremony, but occasionally constitutes the entire rite. The couple eat, drink, or smoke together, and are therefore married. But a general feast has another object—the consolidation of pleasant relations between the two groups, even if no trace remains of the magical link between people who have eaten the 'same salt.' The curious tabus that, especially in Africa, prevent a young bridegroom from meeting or speaking to his mother-in-law, are sometimes lifted when the bride becomes a mother. In some parts of the Pacific this tabu is extended to both parents of a girl—the son-in-law must scrupulously avoid them.

LESSON TEN

Crime and Punishment

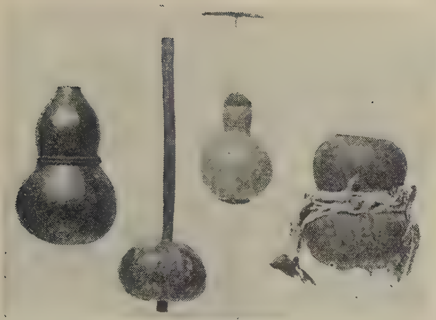
No people, however simple in their system of living, are without social laws, conceived in what are considered the interests of the community; and the existence of laws necessarily entails a means of enforcement, and the exaction of penalties. The origin of law is custom, and the larger and more coherent the community, the greater extension has the crystallized code of laws, the more definite and ineluctable is the exercise of justice. People living in small family groups, as the Alakalufs of south Chile, who wander at will and own no chief, have less need for social rules; but even among such folk, possessing practically nothing but their canoes and a few implements, with no settled habitations, there are distinct rules of conduct, accepted customs, which are rarely defied.

Social Restraints. Lawlessness, or action contrary to the established rules of society, is much more rare among 'savage' races than in modern and highly civilized communities: organized crime is unknown. There is less chance of escape, the opinion of society inhibits more drastically, and the rewards of successful law-breaking are smaller. The restraining influences of custom and discipline are strong; injunctions are binding. One has but to look at the drawings in the Mendoza Codex (now at Oxford), executed by an Aztec artist, showing the training and discipline of children under Aztec rule, to realize that the boys and girls who were taught at such tender ages to perform household tasks, who were so rigidly rationed as to food, and who were punished by stoic parents with pricks from aloe leaves or the suffocating fumes from fires of hot peppers, were far more sternly disciplined than are the majority of children today.

Perhaps the chief broad difference between primitive morality (or obedience to rules of conduct) and that of the modern world lies in the fact that among, for instance, African tribes, social rules apply only to the members of the group. Stealing or personal violence (the two chief causes of trouble, together with quarrels about women) are wrong when occurring within the group, but almost worthy of praise outside the tribal bounds; a stranger may be robbed or even killed without reproach. Many actions, too, which seem shocking to us may be blameless to the people practising them, perhaps because they are, basically, advantageous to the common life of the community.

When we understand these ideas, we might be, as Deniker remarks, 'less severe on a Dyak who cuts off a man's head solely that he may carry this trophy to his bride; for if he did otherwise he would be repulsed by all and would not be able to marry.'

It is perhaps even more difficult to reconcile oneself to the simply utilitarian custom of certain South American tribes who kill or abandon aged folk because they are a burden on the community, or others who kill deformed children. By the custom of society, these acts are blameless. Other



NATIVE TESTS FOR CRIMINALS. In this outfit belonging to a Nyasaland medicine-man the objects are, from left to right: (1) gourd for holding magic potions; (2) rattle used by the diviner of the future; (3) gourd threaded on a string used to identify a guilty person, as described in the text; (4) gourd holding bone dice thrown to indicate a criminal.

examples of primitive law, frequently unintelligible to observers at first, are found in the strict tabus of Melanesia, Polynesia and Australia; these interdictions generally have a practical basis and are rarely broken.

Justice by 'Palaver.' Punishment is frequently assessed by tribes in Africa and many other regions in public assembly. Torday remarks that the administration of justice among the Ba-Mbala folk of the Congo may be summed up in the single word *milonga* (palaver). He gives as an example the stealing of a goat by A, of the village X, from its owner B, of the village Y. A brags of the feat; B learns the truth and sends a messenger to the thief asking for *kama-kumi* (usually some trifle of foodstuff).

If A refuses, war is made on his village; if, as usual, he consents, the crime is admitted and A assumes responsibility. B's next act is to send an arrow to A's chief, incised to show the number of days intervening before the *milonga* will be held. When the day arrives, not only the whole population of the villages of A and B, but of all the neighbourhood, flock to B's village, armed with bows and arrows, to take part in the trial. There is no judge; the decision is left to the crowd. Men of noted eloquence speak on behalf of each party, and the discussion begins. A admits that he stole the goat, but did not B's grandfather seduce A's grandfather's wife? B allows this, but asserts that A's grandfather stole a fowl from B's father. A does not deny the offence, but recalls the fact that a pig was stolen from his uncle by a slave of B's grandfather's brother-in-law. And so the case proceeds, the assembly declaring after each charge and counter-charge that the matter is compensated. Eventually he who can bring the greater number of charges against his adversary is declared the winner and claims compensation. This gives rise to further discussion; if one demands twenty goats the other offers one, and the argument often lasts several days.

An agreement is usually reached; if not, war results. Often the man calling the *milonga* loses his suit.

Trouble over Women. Interference with women on the part of outsiders is frequently a cause of trouble in primitive communities; as a rule, violence is not charged, but attempts to win the affections of a married woman are common. And all over the world a cause for deep anger on the part of the community is the consorting of a man with a woman whose relation to him falls within the prohibited degrees. In some parts of

THE WITCH-DOCTOR DELIBERATES. The belief that the witch-doctor or medicine-man possesses the power of being able to 'smell out' criminals by means of dice (as seen in this photograph) or other objects is well calculated to make the African native submissive to their claims.

Photo, W. H. Craft

Africa the chief assesses the punishment for a breach of the law, but the family of the criminal is made responsible for carrying out the sentence. The responsibility of the kin of a defaulter goes even farther in other regions, where, if a criminal has run away, his nearest relative receives the beating or is mulcted of the fine.

Trials by Ordeal. 'Trials by ordeal' of accused persons are actually appeals to occult powers, and are often chosen by the alleged criminals. These tests occur all over the world, and survived in the British Isles until comparatively recent times. The underlying idea is that the spirits know and will manifest the truth hidden from human eyes, and in some regions of Africa certain objects are used by wizards to 'smell out' evildoers; the tail of a gnu, for instance, can be held in the witch-doctor's hand, and when he has 'smelled out' the wanted man, the tail is switched across the face. In other cases, dice made of bone, carved wood or seeds are thrown on the ground and the guilty person is indicated by the relative positions taken by the dice. Among the natives of the Kasai district the fetish-man identifies a criminal by means of a block of wood rubbed with herb juices as described in page 11. Another method is to use a gourd threaded on a string, the lower end of which is held by the foot. The gourd is allowed to run down the string while names of suspects are recited. When the gourd stops, the name last mentioned reveals the culprit. The hole in the gourd is curved, so that slight pressure on the string will check its fall. Often the person thus discovered is a rich old man who can be mulcted, or an old woman whose tongue is long.

In trials by ordeal the accused may undergo the test of fire or water, (*see* page 11) or of poisonous substances. He may plunge in the sea or river; or, when the trial calls for endurance of heat, he walks barefoot on hot metal or stones, jumps over a blazing fire, or has to handle molten metal. Poisonous herbs are often used for trial by ordeal. Ideas of thus discovering guilt or innocence are common in Borneo, Siam, Malacca, India and many parts of Africa.

LESSON 11

Strange Treatments of the Sick

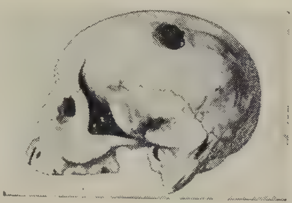
GOOD health, among most primitive peoples, and the full exercise of bodily and mental faculties, are considered as a man's normal state; sickness is regarded not as derangement arising from natural causes, but as the result of a maleficent influence. Often it is caused by an evil spirit or by a personal enemy, and in such cases the cure consists in exorcizing the spirit, or in discovering the adverse human influence and dealing out punishment.

When a Soul has been Stolen. Among the San Blas Indians of south Panama, a person is sick because his or her soul, or *purba*, has been stolen by demons; it is the task of the doctor-priest to recover this ravished soul. Unless it can be brought back to the suffering body within a reasonable time, the patient must die. The sick man, stretched in his hammock inside a darkened hut, is fumigated with aromatic (and especially narcotic) herbs, while magically endowed objects are placed near by; meanwhile, certain little figurines, the famous *suar-mimi*, carved from a special tree, are brought out by the doctor. They are asleep, but are quickened to life by songs known only to the initiated, and then are instructed to go to the land of the demons and by guile and counter-magic to find and bring back the stolen soul. If the *purba* is found in time, it is coaxed, by other special songs, to re-enter the body of the sufferer, when all is well. A similar idea of temporary absence of the life-spirit causing sickness is found in other regions of the New World among the Indians of the north-west coast of America, and has been already referred to (*see* page 12), together with the means used by the Pukapuka medicine-man in the Pacific to catch the errant soul in a special trap.

In certain regions of north Brazil, pain is thought to be due to the entrance of an insect or reptile, and the medicine-man, with extraordinary dexterity defying detection, applies his mouth to the affected part of the body and presently produces a large butterfly or other creature which is assumed to have caused the trouble.

Removing the Evil. Blood-letting, to remove the evil in the patient's system, is of very ancient origin and practically world-wide. Sometimes the sufferer is shot at with small arrows; sometimes knives are used.

Much more drastic was the operation of trepanning, or removing a piece of the patient's skull, to let out head pains, practised in prehistoric times in Europe and in South America. Skulls found in graves of Peru, both of Inca and pre-Inca times, and preserved in London in the Wellcome Medical-Historical Museum, show that trepanning was performed by ancient surgeons upon patients of rank. In some cases the process used is apparent. A series of holes were drilled with stone tools in the skull, until a ring of these circular openings, nearly touching each other, was complete; only a minor series of cuts or taps was then needed before a disk could be lifted up. It seems surprising that anyone could have survived such a process; but modern anatomists agree that, in many instances, the patient lived for several years afterwards. The primitive masseur, as well as the surgeon, was a person of importance: kneading of the muscles to restore vigour and relieve pain is one of the most ancient medical treatments, and was particularly popular in Africa, where, however, the native operator uses his feet as well as his hands, and tramples upon the extended body of the sufferer.



LETTING OUT THE EVIL. The hole cut with sharp flints in this prehistoric skull was intended to permit the escape of evil spirits which caused head pains. The operation is known as trepanning in modern surgery.

Royal College of Surgeons

Primitive Medicine-Chests. Frequently, however, the *curandero* is content with the administration of medicines, and especially of decoctions (usually, but not exclusively, of herbs), with three special objects in view: they serve as sudorifics (sweat-inducers), as purgatives, or as emetics—and it may be noted here that modern European medicine has received gifts from the pharmacopoeia of the primitive medicine-man. It is but necessary to recall the fact that quinine was a remedy of prehistoric Peru, and that ipecacuanha and sarsaparilla, damiana and coca are all, similarly, products of South American forests known to native folk long before they were utilized by ourselves. Quinine, extracted from cinchona bark, was used to allay fevers by the ancient Quechua of Ecuador and Peru, became known to the Spaniards after the conquest, and thus found its way to Europe. The coca-leaf, basis of cocaine, is another product of the American west coast, and in its native habitat serves as a gentle stimulant. It allays hunger on the long mountain trails, and fends off attacks of the dreaded *soroche*, or mountain sickness.

SIMPLE CURE HELPED BY FAITH. The African witch-doctor is not solely dependent upon the effects of magic on his credulous patient. He is shrewd enough to combine simple treatment methods of proved value with an element of the mysterious, thereby gaining the patient's confidence and effecting a cure. Here cupping, a form of treatment still employed in Europe, is being used to soothe an earache.

Photo, Barnabys, Ltd.

The sweat-bath, as a treatment for sickness, was and is used by primitive folk of Arctic Asia, and was a favourite remedy of the Aztec of the Mexican highlands. Near Mexico City examples of this steam-bath are still to be seen by the wayside. They are small chambers, built of the light volcanic stone, of a dull pink colour, called *tezontli:* a furnace was lighted at one side, water poured on the heated stones, and the vapour enveloped the sufferer. This *temazcalli*, or steam-bath, was under the special protection of the Aztec goddess Teteoinnan, patroness of doctors and midwives. The chief shrine of Amimitl at Cuitlauac was until recent times the resort of sufferers from dysentery and chest troubles.

For primitive tribes healing is a miracle, and the 'medicine-man,' even when employing methods resembling those of a modern doctor—such as massage or a hot fomentation—is shrewd enough to base them on the theory of casting out a malignant spirit by making it too uncomfortable for it to haunt the patient any longer.

Faith is an essential part of the treatment of simple folk, and to make the patient believe that evil has gone out of him is halfway to cure. Hence the good results from such conjuring tricks as the apparent extraction from a sick man's body of a quartz crystal which some ill-disposed person is supposed to have shot into him by the force of his curses. Or, conversely, the medicine man will affect a cure by seeming to produce a similar crystal from his own body and making it disappear into that of his patient.

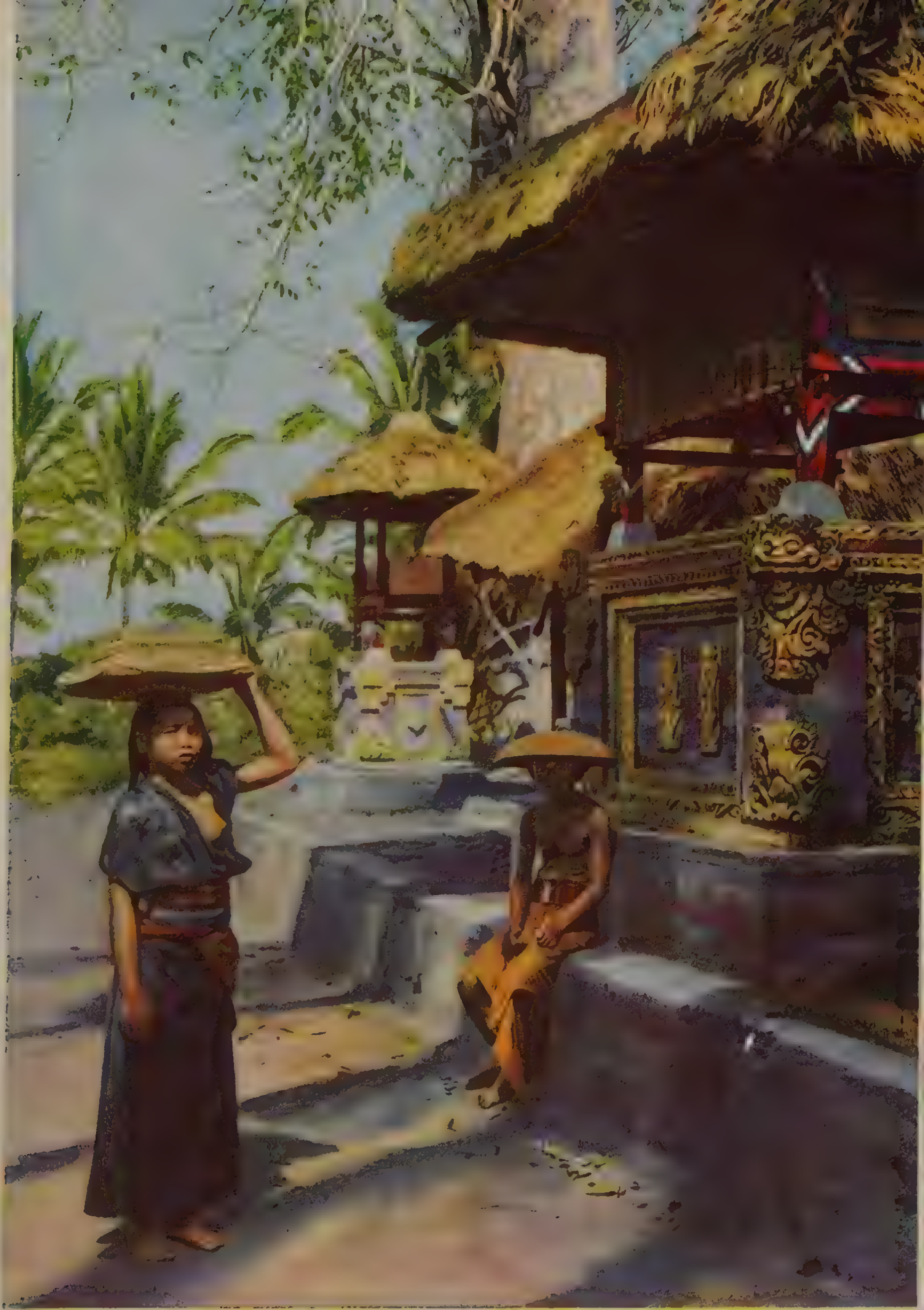
Devils of Disease. Sickness among the ancient Aztecs was often supposed to be caused by angered ghosts or deities. The Ciuapipiltin, spirits of women who died in childbirth, attacked children with malignance; the god Xipe punished by inflicting diseases of the eyes and the skin.

The Aztec idea that sickness was caused by the annoyance of deities, or by touching some special plant, is allied to the worldwide concept of primitive folk that disease is an exterior infliction, to be cured by special means which have little or nothing to do with ordinary care of the body. In Ceylon, so certain is mankind that sickness is something foreign to his normal condition of health that it is usual for a kind of play to be staged when illness is rife. The assistants of the medicine-man put on costumes depicting particular diseases, their masks typifying a special fever or other sickness; these unfortunates are then engaged in combat by the medicine-man himself, who invariably routs the disease impersonators in a series of triumphs.

It is commonly supposed that primitive folk, living under more natural conditions than ourselves, were gifted with better health; but this may be an illusion, partly due, perhaps, to the suppression in infancy among some tribes of sickly and maimed children. The graphic portrait-vases of the northern section of the west coast of South America (particularly proto-Chimu) illustrate the effects of certain diseases and malformations; it is plain that these ancient people suffered from skin troubles and malaria, as well as other scourges.

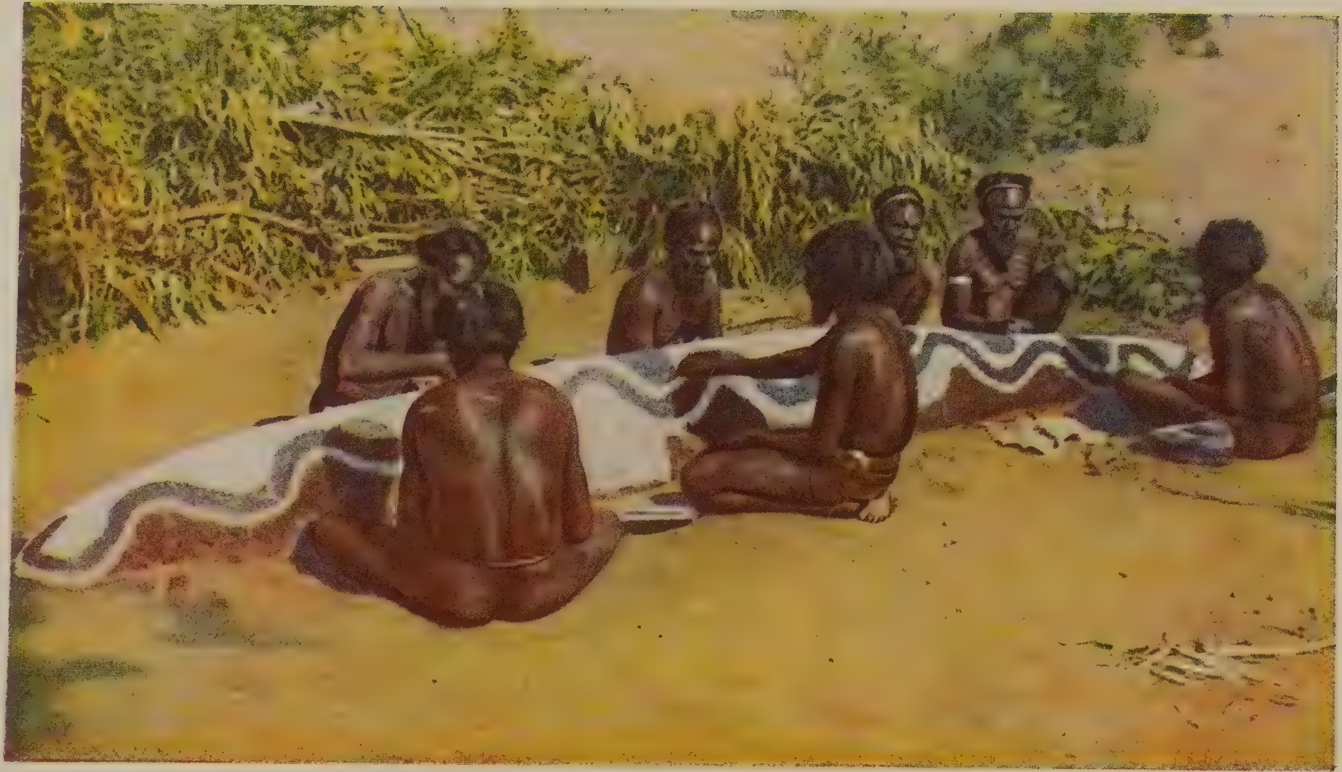
EXORCIZING THE DEVILS OF DISEASE. Under the belief that disease is caused by spirits, or devils, who have taken possession, many races in the East cast them out by the so-called devil dances, as in this example from Ceylon. In fantastic mask and costume they perform ritual dances to the accompaniment of strange music.

Photo, E.N.A



BALI RICE STORE. The origin of rice, as of other cereals, is obscure because of its antiquity. Its home was in China and India, but it spread widely in the East. In Bali an island of Dutch East Indies, the staple food is stored in paddy holders raised on finely carved basalt pedestals.

G. P. Lewis



SERPENT TOTEM OF AUSTRALIAN ABORIGINES

Among most, if not all, primitive races the practice of magical rites is an important aspect of tribal life, often developing into religion. Magic and religion overlap and distinction is difficult, but they are linked by symbolism, a factor which survives in the modern community. Here Australians are seen building a totem mound to placate their benefactor, the Wollunqua, an immense black serpent believed to dwell on the Murchison Range. Others will dress as snake men with elaborate symbols to work magic over ordinary serpents to ensure the tribal food supply of the reptiles.

Spencer & Gillen, 'Across Australia' (Macmillan & Co., Ltd.)

LESSON 12

Property Systems

The system by which property is held among primitive tribes depends to a very large extent on the mode of production. Weapons and tools made by an individual are his private property, but there are many occasions when that individual needs the co-operation of his fellows.

Among hunting tribes it is often necessary for several men to combine in the pursuit of big game, and the resultant bag is shared. Instances are many: buffalo hunting, by the Plains Indians of North America; whale hunting, by the Eskimo; kangaroo hunting, by the Australians. Distribution of the spoil often follows definite rules, more particularly in the buffalo hunts in America, where the owners of the arrows which struck the beast had the right to certain portions of the carcass, according to the relative positions of their shafts—the skin being claimed by the hunter whose arrow struck nearest the heart. Amongst agricultural peoples, where, under conditions which permit settled life, the art of building tends to develop, the house constructed by the combined efforts of members of a family may often become the common property of the builders. In such circumstances many objects of personal property become family property, and with the growth of population this family joint-ownership develops into the village community.

Property in Land. This brings us to the question of property in land, a subject which has frequently given rise to serious troubles in the history of colonization. In wide areas, comparatively thinly populated by nomadic or semi-nomadic hunting tribes, the question is simply that of the right to pursue game in a definite district. That right is enjoyed by all members of the tribe or group, and is jealously guarded. Horticultural and agricultural peoples, living in permanent villages and dependent upon cultivation for their main food supply, tend to develop a sense of private tenure. In spacious countries, where villages are sparse, no difficulties arise. Individuals clear bush at need, and plant in accordance with the necessities of their families, often with the help of neighbours, to whom they render like service. In the early stages of plant cultivation, by folk ignorant of the principle of crop rotation and employing no fertilizers save the ashes of the burnt bush, plantations become exhausted and new clearings are made periodically. Thus it not infrequently happens that the cultivated land becomes inconveniently remote from the settlement, and migration results.

AFRICAN RIGHTS IN LAND. Among the part-nomad, part-agricultural tribes of Africa land tenure is on a tribal basis, and in spacious countries becomes a simple matter of meeting the needs of individual families by burning fresh areas of jungle as the previous clearings become exhausted. In this photograph nomadic farmers of southern Nigeria are clearing an area by fire. When the remaining fertile land is too far from the village for convenience, the whole tribe migrates to a new forest centre and repeats the process.

Photo, R. St. Barbe Baker

Rules of Primitive Hunting. Such methods are particularly characteristic of the agritural tribes of Africa. All these tribes hunt

PROPERTY IN HUMAN BEINGS. Until recently, slavery continued to exist in Liberia and Abyssinia, though it was of a domestic nature, originating in debt or by capture in tribal war, and involved little hardship of any kind. Many Abyssinian princes owned enormous numbers of slaves. The file of men in this photograph were bond servants of an Abyssinian lord, and are seen carrying to their master gifts of food and drink. In 1931 the Emperor Haile Selassie issued an edict forbidding slavery.

on occasions, and though the rules of primitive hunting are observed in so far as the hunter who, in the communal drives, inflicts the first wound is entitled to the animal, he must in certain regions give a leg to the occupier of the land on which it is killed. Although in circumstances such as these the occupation of land seems, on the surface, to be a simple matter, it is not quite so simple as it appears. In reality, colonization in Africa has shown that property in land is vested in the chief on behalf of the community. Troubles have occurred on the death of a chief from whom the leaders of a trading or mission station have purchased land, because the successor has demanded further payment. Freehold, as we understand it, does not exist in Africa; there are only tenancies, which lapse on the death of the chief who granted them.

Similarly, amongst the cattle-keeping Ankole in east Africa, all cattle are royal property. The king allots herds to the provincial rulers, who, in their turn, distribute them to the village chiefs, The lord of a province can punish and ruin a village chief by calling in the cattle allotted to him, and the king can degrade a provincial ruler by the same method. The king is the owner of the beasts, while the temporary possessors have only the usufruct, i.e. the milk and a certain percentage of beasts for slaughter. The fine of a number of cattle imposed by an inexperienced administrator upon an erring headman years ago nearly resulted in a serious uprising; it was regarded as a direct insult to the king. Fortunately, the crisis was solved by explanation.

Plantation Rights. To return to the primitive planters. In restricted areas, with limited fertile land and a growing population, rules of tenure are more overt and explicit. The Pacific islands and ancient Mexico yield cases in point. Fiji affords a good illustration. Residential land, where huts were erected, was the result of settlement, when tribal retainers built their huts around the hut of the chief. But there were certain rights to plantation land as far as the original planter could be traced.

Sir Basil Thomson writes:

> The *nkele* (plantation land) is simply that portion of the *veikau* or forest that has been appropriated. Once appropriated, it descends according to the fixed law of inheritance. But the ownership of a proprietor is strictly limited. There is no more absolute ownership known to the Fijian customary law than there is to the English. ‘ No man is in law the absolute owner of lands. He can only hold an estate in them ’ (Williams, ‘ Real Property ’). The tenure of the *nkele* may be best compared to an estate for life. Each owner holds for the household to which he belongs; the household holds for the sept, the sept for the clan, the clan for the community, and the community for posterity. The owner of the *nkele* had over his land a little less than *dominium* and a little more than *usufruct*.

Clans in Ancient Aztec Mexico. In ancient Mexico, where a teeming population, living in the main on agricultural produce, occupied the islands and shores of the lake, the series of invading tribes which descended upon the valley of Mexico naturally, in turn, seized land by right of conquest, and the chiefs allotted lands to their dependents, many of these grants being effective only for life. But there were other lands, held in common by the local clans, composed of the descendants of the different families of the invaders, and of the tribes who attached themselves to the latter in early days. These clans were known as *calpulli*, and eventually were transformed, under the Spanish régime, into *barrios* or 'wards.' Land belonging to a calpulli was inalienable, although under certain circumstances it could be rented to another calpulli. The property was vested in the calpulli chiefs, from whom individual members obtained tracts sufficient for their needs, which they held as long as they kept them under cultivation. Otherwise the land lapsed to the calpulli, and a man who moved lost his holding.

Inca State Socialism. Peru provides another picture. Under the Inca régime, which was in full flower at the time of the Spanish conquest, a system of state socialism, almost perfect in detail, had been developed. The Inca people had become a ruling caste, and there was no property except crown property, apart from the small tools which every man made for himself. An enormous body of overseers controlled the labour of the 'empire.' Crops were stored in government granaries, and distributed over the country; raw materials were issued to artisans, and their finished products, collected as 'tribute,' were treated in the same way. By this means it was possible to populate large tracts of the sterile highlands, where llamas and alpacas were bred, but where the altitude and poverty of the soil prohibited agriculture. In the arrangement of their 'empire,' the Inca rulers often deported whole villages of conquered tribes to unpopulated areas. Usually, the nearest folk with whom the deportees were in contact spoke a different dialect; this was a safeguard against revolution. There was no poverty, but no personal freedom. Apart from the ruling class, every man died in the same state of life as that in which he was born, and no man could leave the community of his birth.

Lot of the Slaves. Another form of property is that in human beings—slavery. There were many forms of primitive slavery, none of which resembled in the least the slavery of the American States as depicted in 'Uncle Tom's Cabin.' African slavery was, in the main, a light thing. A man could become a slave by capture in war, or by reason of debt—his own or his father's; but it is quite a mistake to imagine that domestic slavery of this kind involved ill-treatment. A slave was an asset, and no man would wish to incapacitate a labourer who was working for him. Among many west and central African tribes the slave was allowed to collect money by private enterprise whereby he could buy his freedom. His master had to supply him with a wife, and was even responsible for his debts. Recalcitrant slaves might, in certain districts, be sold to other tribes for sacrificial purposes, and slaves who had risen to high office in the service of a chief might be sent to the other world at the death of the master. The domestic slavery of Africa involved little hardship, apart from this, and the slaves, free of any responsibility and assured of maintenance, were often the most contented section of the community.

LESSON 13

Primitive Interchange of Goods

When humankind began to live in communities, interchange of commodities also started, within and without the social group. Even among the hunting tribes, a member of the group might find himself with a superfluity of meat, and the obvious course was to make some exchange with, say, an individual who was an expert maker of stone arrow-heads. With settled life, based in the main on cultivation, which gives opportunity for the development of arts and crafts, specialization in small manufactures increased, and at first the surplus of individual production was no doubt absorbed by the needs of the group, organized, to a certain extent, on communistic lines.

But, as agriculture and handicrafts developed, production often outran the needs of the group. Production of this intensive nature had two bases: first of all, environment; secondly, tradition. Tribes settled in regions suitable for the cultivation of certain crops became exporters to neighbours in less fertile surroundings. Other tribes inhabiting districts rich in workable clay or mineral deposits exchanged products with groups who could provide necessary commodities.

The copper mined and worked by tribes of the Katanga province, in S.E. Belgian Congo, spread from tribe to tribe to the West Coast. The pottery most prized by the Aztec was manufactured by the Toltec population of the province of Cholula, just as Chinese porcelain became prized in Europe. While environment gives the material, tradition consolidates and, to some extent, restricts production. Crafts become organized, and the right to pursue them becomes the property of certain families who know the trade secrets, and, more important still, the magical formulae and tabus which render them almost unsafe for the uninitiated to pursue. In Samoa house-building was a close craft, and our own guilds, especially the great craft of masonry, have their origin in the same idea. Even the immigration of a stronger people does not necessarily kill an indigenous craft, because the right of the aborigines is recognized by the incomers. Hence the fine spear-blades of the Masai (who knew no iron-magic) were manufactured by the subject tribe of El-Konono, and the Aztec invaders relied on their Toltec subjects for pottery. An interesting instance of the death of a craft is provided by the Banks Islands, when the last of the weaving fraternity, an old man, passed away without relation or apprentice to whom he had communicated his secrets.

In this simple form of exchange, the transit of commodities from tribe to tribe often covers distances which are surprising. For instance, glass beads of European manufacture have been found in pre-Spanish native burials on the island of Marajo, in the Amazon delta. These must have crossed the continent from Peru or Ecuador. Maize, too, had become the staple food of half Africa within a century of Columbus, covering a region far beyond the radius of European exploration at that period.

Trading Expeditions. At the same time, systematic trading expeditions are by no means unknown to many peoples whom we regard as primitive. To take a simple instance, within recent years, of a man making a short trading tour in the Kwilu District of the Belgian Congo: possessed of 8,000 *djimbu*

TRADE IN THE JUNGLE. Despite the penetrative successes of Western commerce, primitive methods still survive among the more backward tribes in out-of-the-way corners of the world. This photograph shows a market in the jungle of Borneo, where the nomadic Punan hunters barter meat, skins and hides for cooking utensils, weapons, mats and rice.

Photo. F. Kingdon Ward

(small shells, the lowest denomination of local currency), he was able to buy ten goats in Kolokoto, where goats were cheap. Travelling to Lukula, he exchanged the goats for 250 balls of rubber. The rubber was sold to a European trader for 62½ kgs. of salt, with which two slaves were purchasable. These two slaves fetched 20,000 *djimbu*, and this sum was exchanged in turn for 25 goats in Kolokoto. Thus the merchant obtained a profit of 150 per cent in about a month quite easily.

Organized trading on a larger scale is also old in human history, as witness the old trade-routes connecting Europe and Asia, and the voyages of the Phoenicians. Returning to Africa, we have the paramount instance of a trading tribe, the Badjok (also called Kioko) of Angola, who, in large groups, traversed Africa to and fro from Angola to Mozambique in the perfect assurance that any violence offered to one of their caravans would be terribly avenged by the next.

Aztec Merchant Guilds. Even more elaborate was the system of trade under the Aztec rule in Mexico. Here, in pre-Spanish times, was a kind of guild of travelling merchants, the Pochteca. They had their own patron god, their own particular religious ritual, and their own burial ceremonies. On foot, they traversed enormous distances, penetrating even to the lowlands of Guatemala, and constituting a most important intelligence force for the Aztec imperial government. As a close corporation, with special privileges, they were protected officially, and the murder of one of the guild in a far country involved military reprisals on the part of the Aztec government.

New Guinea. Organized trade, again, in a high degree of development is found in New Guinea in pre-European times, and survives today. Practically all this trade is sea-borne, and involves the building of sailing-canoes of considerable size, capable of withstanding heavy weather. The laying down of a boat, the building, the rigging and preparations for the voyage involve a whole host of ceremonies and tabus, which are far too elaborate to describe here in detail. But the result is that the inhabitants of the districts who concentrate on pottery-making, the manufacturers of stone adze- and axe-blades, and the cultivators of sago, interchange their respective products over a very wide field. Such trading voyages can be grouped in series, covering definite areas, and the most interesting is the *Kula*, which is in vogue in the south-east end of New Guinea and the adjacent islands (Louisades, Woodlark, Loughlans, Trobriands, and d'Entrecasteaux groups). The primary objects of this trade are shell armlets and shell necklaces, but they circulate in opposite directions, according to a definite traditional rule. The necklaces go clockwise round the trading circle; the armlets, counter-clockwise. But these articles serve no real utilitarian purpose; they are hardly ever worn as ornaments, and it is not etiquette for the temporary possessor to retain them for any length of time. A man engaged in the *Kula* traffic has a number of ‘ partners’ in other islands, who will give him hospitality on a visit, and to whom alone he can offer these objects of value. Nowadays a native will give the equivalent of £20 for a good specimen. To quote Professor Malinowski:

> An overseas expedition arrives in my village. Blowing a conch-shell, I take my armshell pair and offer it to my overseas partner with some such words, ‘ This is an initial gift, in due time thou returnest to me a big necklace for it.’ Next year when I visit my partner's village, he is either in possession of an *equivalent* necklace, and this he gives to me as a restoration gift, or he has not a necklace good enough to repay my last gift. In this case he will give me a smaller necklace—avowedly not equivalent to my gift—and will give it to me as an intermediary gift. This means that the main gift has to be repaid on a future occasion.

But though these ceremonial objects are the overt reason for the lengthy voyages, the practical effect is the distribution of a large variety of commodities over a very wide area—subsidiary, in native estimation, but paramount, economically.

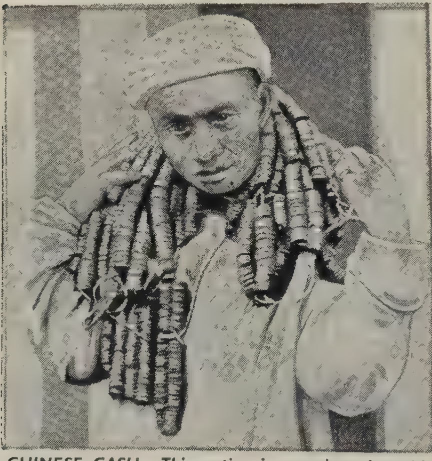
Trade under the Incas. A complete contrast is afforded by the really efficient organization of the Inca ‘ empire,’ which at the time of Pizarro extended from Quito in Ecuador to the River Maule in Chile. As already described in the last Lesson, there was no such thing as trade. All produce was collected by the State, and distributed. The Inca tribe had become a ruling caste, an exaggerated Civil Service, supervising the many subject peoples under its domination. Agricultural produce was stored in State granaries, and was distributed according to the needs of the various districts. Heads of families living in agricultural districts were allowed land according to the number of their dependants, but all surplus production was State property. Artisans worked for the State, and received State support. Only their personal tools and gear were buried with them, to serve in the other world.

LESSON 14

Shells, Feathers and Other Currencies

The interchange of food products and the results of man's handiwork were conducted, no doubt, by simple exchange in the beginning. But the method was not convenient, from two points of view, because the value of commodities was even less regulated than today. With us, the price of food rises if there is a shortage; but there is, nevertheless, some form of standardization, a market price, so that a starving hunter need not be forced into parting with his best knife for a couple of potatoes. Secondly, direct exchange is not always easy. A may have a surplus of yams, but be in need of fish-hooks; B has fish-hooks to spare, but wants bark-cloth, not yams. So A and B have to find C, who is ready to exchange bark-cloth for yams.

'Silent Trade.' This form of barter by direct exchange must have persisted for years in human history, not only within the tribe, but in foreign relations. In the Western Pacific the sea-going folk would lay out their trading wares on the beach, and retire to their ships. The inlanders would then descend and deposit beside them what they considered an adequate exchange. If the sea-folk were satisfied, they collected the wares offered; otherwise they left them lying, as an intimation that they did not regard the exchange as adequate. The inlanders then either removed their own property, or supplemented it. This form of barter, known as the 'silent trade,' in which the parties did not meet personally, has been practised in many parts of the world.



CHINESE CASH. *This native is carrying about his neck some thirty shillings' worth of metal cash.*
Photo, Maynard Owen Williams

Gold as the Standard. Trade everywhere received an enormous stimulus when, with the growth of society, certain objects were accepted as measurements of value. Within a very recent period western civilization accepted gold as a standard of value. Everything was valued in terms of gold; silver, bronze, and even paper had their value, but only because they represented gold. Gold had become 'currency' and a medium of exchange. Now, the ideal form of currency is some object which is fairly consistent in supply but not too common, or, if it is common, one that must be put into some form entailing labour. Further, it should consist of a more or less permanent material. The Western world selected gold because it complied with the first of these conditions; it is incorruptible, and is of no use for anything except ornament. No cutting tool can be made of gold, yet it is immune to practically every corrosive agent.

Shells. Primitive tribes, especially those in the Pacific Islands, which hold no metallic ores, selected shells as their currency; these are common enough on the beaches, but were reduced by labour to the small disks which compose native necklaces. The labour was a lengthy process; shells were broken into convenient fragments with a stone hammer; these were assembled, about thirty together, in a wooden holder and patiently ground on both sides on a flat stone. Each one was then separately drilled with a stone-pointed drill, and, next, the pieces were strung and drawn back and forth in a grooved stone until the edges were perfectly smoothed. A *fathom* of such disks (measured between the outstretched arms), comprising many hundreds, would in some islands buy a wife, or two fathoms a pig. Values were complicated, because the red disks were worth more than the white. White shell is easy to obtain, but the red disks could only be obtained from the edge of one particular shell.

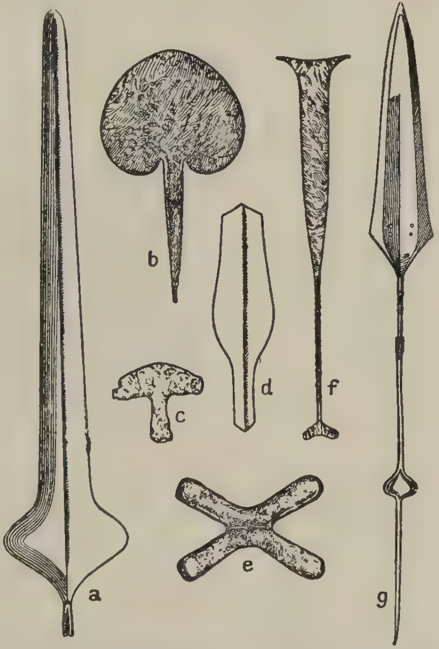
Certain kinds of stone, worked by human labour, were also used for currency. For instance, a good jade adze-blade in New Caledonia was the recognized price of a well-nourished man for cannibal purposes. But here also was another object which was used as a measure of value, perishable but difficult to collect—the hair-string made from the red fur-tufts of the ears of the local bats. The looped cords used in throwing spears were usually ornamented with this fur, and so the spear-thrower became a unit of exchange.

Feathers of High Finance. In the Banks Islands a peculiar form of feather currency was devised. Long coils of bark-fibre were prepared, and covered with small red feathers overlapping like tiles. Such coils represented wealth and were used in transactions involving high finance. The older and more worn they were the greater their value, just as an Elizabethan gold piece will fetch more in the sale room than a Georgian sovereign.

Value varies according to rarity when the particular object has been accepted as a measure of value. Cowries and olivella shells in Africa increase in value in proportion to their distance from the sea. The wampum (shell-bead chain) of the Indians of the North American plains had its value partly because it was brought from the coast, though the labour involved in piercing these fragments and grinding them down to uniform cylinders must have been enormous.

Chinese 'Cash.' Articles adopted as a medium of exchange and a measure of wealth tend to become conventionalized, and provide a step in the direction of coinage. But conservatism prevails, and many useful articles, selected locally for this purpose, become reminiscences of their original form, adapted to the needs of hand-to-hand passage. Perhaps the best example is the evolution of the Chinese 'cash,' the small circular copper coin of infinitesimal denomination, with a square hole in the middle. In early days the Chinese reckoned values, to some extent, in knives. The utility knife had a circular terminal to the handle, pierced with a hole. When knives became currency, the blade, no longer useful, became blunt and then gradually shrank, until it finally disappeared, leaving only the circular terminal as a coin. In the Chinese 'cash' we have what is called a survival, and there are many parallels in the history of human economic development.

Weapons as Money. In Africa, for instance, iron and copper were materials of value. Ingots of copper, in the form of a St. Andrew's cross, travelled from the Katanga throughout the Congo basin, advancing in the worth ascribed to them as their place of origin became more distant. So, too, spear-heads, knife-blades and hoe-blades were all composed of valuable material which could be re-formed for other purposes. Objects of this nature, made merely for trade, were in course of time left unfinished. Spear-blades and knives were not edged. They were simply so much metal in the old forms. On the Lomami River we find spear-blades five feet long, useless for fighting purposes but constituting the most valuable monetary unit. Similar is the hypertrophied throwing-knife, recognized in certain parts of the Kasai as the highest form of currency unit, which bears a definite exchange relation to the equally conventional hoe- and knife-blades of lower value. The elaboration of such conventional units into small change, such as shells or chickens, is the first step towards a coinage.



AFRICAN CURRENCIES. (a) Spear-head, Upper Congo. (b) (c) Hoe-blades, Upper Nile. (d) Axe-blade, Stanley Falls. (e) Copper saltire, Urua. (f) Knife-blade, Sierra Leone. (g) Spear, Lomami river.

British Museum

Instances of survival in local currencies can be multiplied, but two others must suffice. The conventional fish-hook currency, not so long ago employed in Ceylon, was just a length of silver wire doubled on itself and curved into hook form; later it became a double strip uncurved; this points to a time when serviceable fish-hooks formed a unit of value, but eventually were translated into a more precious metal. There is also in Ceylon the case of the small ingots in the shape of canoes, recalling the period when real canoes were employed in exchange.

American Indian 'Potlatches.' In this connexion it is impossible not to say a word about the potlatch ceremonies of some Indian tribes of the north-west coast of America. An invitation to a potlatch feast, issued by a chief to neighbouring tribes, involved the distribution of objects of wealth—blankets, canoes, and so forth. To supplement his own resources, the chief would call on his tribe. Recipients of his bounty were bound in honour to return it, in reasonable time, twofold. Thus the giver of the feast not only obtained great honour, but had made a sound investment.

QUAINT TOKEN MONEY. Upper photo, primitive African currency in the shape of crudely-formed miniature (and useless) weapons. Below, fish-hook money from islands off Alaska.

From the Zerbe Collection

In connexion with these feasts certain copper plaques or shield-shaped objects played an important part. Their number was limited, and they were known. A chief would dare a rival chief to buy the shield, and the invitation could not be denied. The price was on each occasion higher than the last, and in the end a wealthy man would break a 'copper' and his rival had to repay the price, or destroy an equal amount of property. Owing to this destruction, the potlatches were forbidden by the government, but the embargo was most unwelcome to the natives, whose 'coppers' and investments lost value.

LESSON 15

Primitive Ways of Producing Fire

One of the features which separate man from the other animals is the fact that, from very early times, he has used and, as far as possible, controlled fire. Moreover, from very early times, he has invented processes of producing it. Nature points the way and suggests the phenomenon: lightning striking a dead tree; volcanic action, especially in a forested area; spontaneous combustion of rotting vegetation or textile fabrics; possibly, also, the friction of two dead boughs under the pressure of the wind. By whatever natural process he was introduced to it, primitive man certainly used fire.

Like most natural phenomena, fire was regarded as something divine, with a personality of its own. The flickering flames suggest life and movement; its capacity for destruction suggests the voracity of a beast of prey. The Aztec of Mexico represented it as a butterfly, or, less commonly, as a lizard or snake. The latter symbol will be perfectly comprehensible to those who have seen a bush-fire creeping sinuously along the ground in forest areas.

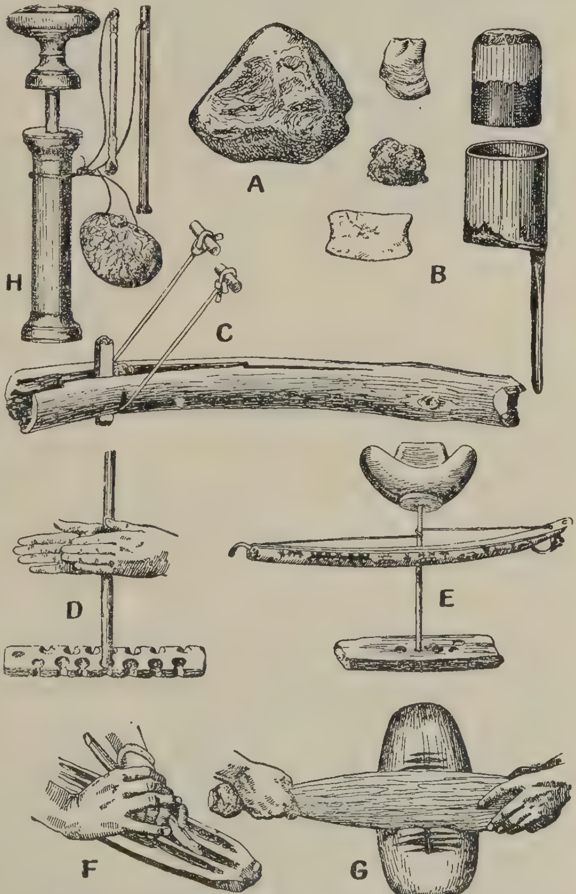
Undomesticated animals are afraid of fire. Man, who captured fire, no doubt used it first for the purposes of protection, warmth and light. Later, with the development of cooking, pottery-making and metallurgy, it became a necessity of human existence, and he had to provide for a continuous supply.

All existing races make use of fire, and the only people who, within historical knowledge, have had no knowledge of producing it is the population of the Andaman Islands. Backward peoples, however, avoid as far as possible the necessity for production, by preserving the means of maintaining the supply. The Indians of Guiana and the very primitive inhabitants of Tierra del Fuego carry fire with them, burning in a 'hearth' (usually of clay) arranged in their canoes.

When Fire Becomes Stale. But there are limits to this preservation. There is a very widespread belief that fire, like all living things, becomes 'old' or 'stale,' and this ageing brings hurt, even disaster, to the community. Failure of crops, murrain on cattle and pestilence are frequently attributed to the growing impurity of fire. Among some communities precautions were taken to avoid trouble of this kind. An instance is found among the Aztecs. At the end of every 52-year period all fires were extinguished in the city of Mexico, and new fire was kindled by the traditional method on the breast of a sacrificed prisoner outside the city precincts. All the inhabitants obtained a fresh supply from this, in the belief that a fresh stimulus was given to communal life.

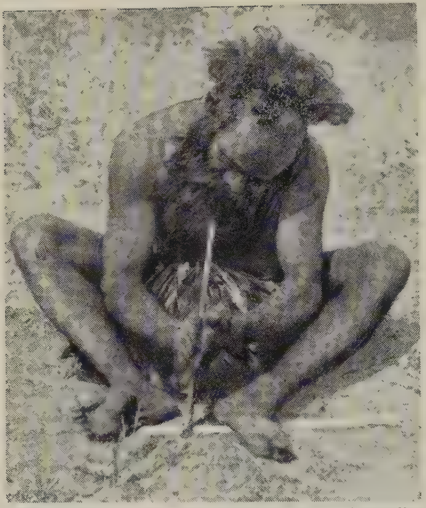
It is not so long since a similar idea prevailed in central Europe, in the case of disease, whether of men, beasts or crops. All fires were extinguished, and a boy and girl, virgin and naked, in the seclusion of a dark hut, created 'pure' fire by the most ancient method known to the population, the friction of two pieces of wood. Instances can be multiplied, but these two, one in each hemisphere, may be taken in illustration. Akin to this idea is the necessity for new fire in religious ritual, exemplified in certain Hindu ceremonies, in which old-world means of production are used, though other and far more convenient methods are quite well known to modern Indian civilization.

Fire Origin Myths. There is no direct evidence to show by what method fire was first produced by man. Most peoples assign it to divine revelation. The Greeks, for instance, believed that Prometheus brought sparks, enclosed in a fennel stalk, from



FIRE-MAKING INSTRUMENTS. A, Lump of ore (Tierra del Fuego). B, Flint and steel (Burma.) C, Wood and bamboo strip (Malay States). D, Twirling (Africa). E, Bow-drill (Eskimo). F, Stick and groove (Oceania). G, Sawing (with spear-thrower on shield, Australia). H, Fire-piston (Borneo).

British Museum: by permission of the Trustees



FIRE-MAKING BY FRICTION. *The Australian aboriginal kindles tinder with the smouldering sawdust produced when a hardwood spindle-stick is made to revolve upon soft wood.*

Spencer & Gillen, 'Across Australia,' Macmillan & Co.

heaven; the Bushongo of the Belgian Congo believe that the secret was revealed to a man in a dream. But the earliest processes can be grouped under two headings: friction and percussion.

Producing Fire by Friction. The frictional processes can be subdivided into three: drilling, sawing and ploughing; while the actual methods differ, the principle is the same. Two kinds of wood must be used, one hard, the other soft. The friction of the hard wood against the soft not only produces heat, but provides for the accumulation of a quantity of finely divided wood dust, which combines easily with the oxygen of the atmosphere, and the dust begins to smoulder. In this condition it is allowed to fall on a small bunch of 'tinder'—usually dried vegetable fibre or fungus. Perseverance produces a spark, which, fanned by the breath, forms a glowing nucleus, and this starts the fire.

For the *drilling* process, the pointed hardwood drill is rotated between the palms of the hands in a cavity in the soft wood 'hearth' laid flat on the ground. There is generally a notch cut in the side of the cavity, to allow the smouldering wood dust to fall out on the tinder placed alongside. The process is difficult, because the hands tend to slide down the drill, and must be raised again in the smallest fraction of time to repeat the process. Any delay allows the drill to cool. Consequently, there are often two operators, one ready to take up the manipulation at the top of the drill as soon as the hands of the other have worked down to the hearth. This method was almost universal throughout the world in primitive times; it was the only one known in the Americas south of the Eskimo, and, with one exception, in Africa. In some cases (notably in the Arctic regions and India) the drill was operated by means of a thong, with one turn round the drill, drawn backwards and forwards by both hands, or by means of a bow operated by one hand.

The *sawing* process consists in drawing a sharp blade of wood backwards and forwards in a groove made in a piece of softer wood, the tinder being so arranged as to catch the smouldering dust. This method is particularly characteristic of Indonesia and parts of Australia. Amongst the Malays the blade is sometimes replaced by a pliable strip, usually of bamboo rind, drawn to and fro along the underside of the 'hearth,' which consists of a split stick, kept open by a peg, behind which the tinder is inserted. Owing to the ease of continuous action, the sawing method affords quicker results than drilling, provided that the hard and soft materials are properly chosen.

Ploughing is more difficult. This process involves the friction of a hard pointed stick in a groove worked out in softer wood. The fine dust rubbed off from the latter accumulates at the end of the groove, until, by accelerated friction, charring begins, culminating in ignition. It is then brushed off on to a heap of tinder and blown into flame. The process requires considerable knack in the regulation of pressure. If the pressure is insufficient, there will not be enough heat to start the charring process; if it is too great, the groove will be worn smooth, and the supply of dust will cease. This method of fire production is especially characteristic of Polynesia, and is occasional amongst Melanesians (Solomon Islands) and Australians. It also occurs, locally, on the middle Congo. Friction will in the end produce a spark; the Eskimo and Aleuts discovered that this result could be achieved by the friction of two pieces of quartz smeared with sulphur.

Percussion. A spark, however, can be produced by percussion. To us the combination of flint and steel is the main fire-producing apparatus within living memory; but iron or steel is not necessary for the production of a spark, and a spark, caught on some form of tinder, will engender fire. Flint on flint, pyrites (a form of iron ore) on flint or quartz, broken china on bamboo (Burma), will produce a spark, while metallic iron on bamboo, flint or quartz provides even better results. So the percussion method is widespread, existing amongst primitive tribes such as the Eskimo and Fuegian, the peoples of Indonesia, south-east Asia, central Asia and Europe.

Fire by Air Compression. The most peculiar method of fire production has been reserved to the last; it is that effected by air compression. The compression of air produces heat, as anyone who has pumped up a bicycle tire with a hand-pump knows. Amongst the more primitive tribes of south-east Asia and Indonesia (locally in Burma and the Malay states, Borneo, Sumatra, Flores and the Philippines), this fact has been exploited to produce fire. The apparatus consists of a small cylinder, blocked at one end, and a piston, accurately fitting the bore of the cylinder, with a knob at the end. The cylinder is made of brass, horn or wood; the piston, invariably of wood, has a small cavity at the end in which tinder is placed. The end of the piston is inserted in the cylinder, struck down with the palm of the hand and immediately withdrawn. The compression of the air ignites the tinder, and fire is obtained. It is difficult to envisage by what accident the principle was discovered, because the appliance exists only among the more primitive peoples of the area.

It appears to have been in common use among the more primitive Indonesians long before Fletcher, in 1801, noted that an airgun gave a flash in the dark, and further experiments in Europe led to the invention, by Lorentz, in 1807, of an analogous (but not similar) appliance for the production of fire. This, known as the tachypyrion, was not used in Europe later than 1834, because it was ousted by the invention of the sulphur match. All the evidence suggests that this is an example of independent invention.

LESSON 16

The Food of Primitive People

It would be going too far, perhaps, to say that man will eat anything. But it is true that various folk, including many of the 'civilized' of today, combine to lay under contribution towards their bodily needs for sustenance not only almost every branch of the animal kingdom, but an enormous number of roots, stems, leaves, fruit and seeds in the vegetable world, and, in addition, explore the secret recesses of the earth itself for minerals to act as condiments and medicines—indeed, man can and does eat earth itself.

Man's Unrivalled Digestion. The digestive power of human beings surpasses that of many other creatures, notwithstanding the legendary powers of camel and goat; and while dietetic experts have no doubt good reason for laying down laws as to the proportion of varied ingredients in a balanced diet for the development and maintenance of healthy human beings, yet the fact remains that millions of inhabitants of this globe have lived, for uncounted generations, upon foods which break all good rules save those of experience.

Certain South American natives of the Amazon belt live, almost exclusively, upon grubs found under the bark of trees; nomad people of Turkistan live, with little variant, upon milk and animal products; there are tribes of Africa whose staff of life is derived from roots dug from the desert soil; in North America powerful races lived 'on, for and by the buffalo,' the chief source of food and clothing.

Strange Items in the Menu. Ants (South Africa), caterpillars (Australia), snakes (South America), lizards (West Indies and Central America), snails, frogs, octopus, sea-urchins—all have their place on the menu of mankind, sophisticated and unsophisticated; also under contribution are such items as nuts, pods and drupes; flowers, like the waxy inflorescence of the 'Spanish dagger,' eaten raw in Central America, or the globe artichoke, eaten cooked all over Europe as well as in its Oriental home; the sweet exudation of blossoms, transmuted by the bee to form honey; the roots of ferns (New Zealand); even poisonous plants are used, when the injurious element has been extracted—as in the case of cassava, in Mexico, Central America and northerly parts of South America; while fermented juices from innumerable stems and fruits form the basis of intoxicating drinks in well-nigh every country of the world.

Man eats fish from seas and rivers, molluscs from the shores; birds and birds' eggs (the Chinese preferring the latter when rendered putrid by long years of keeping); and practically every four-legged animal, including dog, the hairless variety of which was, indeed, highly prized as a dish in ancient Mexico and Peru. Certain birds and beasts of prey—the tiger and turkey-buzzard, for example—are amongst the few creatures practically exempt, throughout the universe, from man's food list. Nor did only prehistoric man eat much of his food raw, but highly civilized folk continue to prefer to eat oysters uncooked, as well as such salad stuffs as lettuce, tomatoes, endive, and many nuts and fruits.

GATHERING SEA SLUGS FOR CHINESE GOURMETS. *Large quantities of bêche de mer or trepang (sea slugs) are gathered by the aborigines of the Coral Sea islands off Northern Australia for the Chinese market. The sea slugs resemble very small cucumbers, and are covered with horny nodules.*

Photo, E.N.A.

Food Collectors. The earliest peoples seem to have collected their food, whether they lived on roots and other field or forest products, or added the eggs of wild birds, and shellfish, to their brief meal list: neither weapons, nor traps, nor any special equipment were needed. Later came the hunter's effort to kill live creatures for food, and the concomitant invention of knives, throwing spears, and bow and arrow.

SNAILS FOR SALE. *In France and the adjoining countries snails constitute a much appreciated item in the menu, and in many districts there are farms devoted to their cultivation. This photograph shows a youthful vendor of 'chiocciole' or small snails at Girgenti in Sicily.*

Photo, E.N.A.

Dwellers in forest regions were (and frequently still are) so closely dependent upon their environment that they do not wander; this localism explains the long survival of such primitive folk. Unchanged because the forest is unchanged, they are, equally, survivors of prehistoric times. In Asia the Veddas provide a striking instance.

Hunters and Fishers. The second category, of hunters and fishers, have had a stormier racial history, for, as dwellers on plains and coasts, they have had to withstand the inclemencies of climate while exercising ingenuity in finding food and shelter. Eloquent proof of the menu of the fisher and hunter of previous centuries is found in the 'kitchen middens' of Denmark, the West Indies, Brazil and Chile. On the south coast of the last-named country, the Fuegians are exemplars of tribes still living in the Stone Age, as collectors of berries and shellfish and as nomad fishers, all living precariously upon food obtained from day to day. Similar collectors, with no method of storing foods, are the Semang of the Malay Peninsula, who do, however, hunt with a blow-gun, and the Kubu of Sumatra, nomads with no methods of agriculture or storage.

A 'KILL' IN THE KALAHARI. *Among the most primitive of modern peoples are the Heikum bushmen of the Kalahari desert. Homeless nomads, they stalk their quarry with stealthy cunning, shoot it with a poisoned arrow, and follow its spoor until it drops dead from the effect of the venom.*

Denver African Expedition

The pygmies of Africa and the Botocudo and Macu of South America are likewise dependent upon day-to-day food gathering.

The next group in advancement is that of the intensive collectors and hunters, whose economic system is usually founded upon one species of plant or one animal. For instance, the whole life of the Pomo, Maidu and Miwok tribes of California is based upon the acorn; that of the Menomini, Dakota and Ojibwa, of the Great Lakes, upon wild rice.

Wanderers in Search of Food. Such folk have for centuries led a restricted nomadic life, with regular seasonal movements. Winter quarters, where habitations are built, and where storage is made, are occupied every year after the harvest is over; in the following spring the region is deserted and migration is made *en masse* according to the ancient plan. As the tribe moves bodily, the beginning of organized cooperation and of arranged division of labour is seen in the life-story of these traditional collectors. Semi-nomads, they are unable to carry fragile domestic utensils; pottery is, therefore, scarce, but basketwork fine and good; and though in such cases arts and crafts are still elementary, there is a marked advance upon the life of the day-to-day collector in that plans are made for the future, and it stands to reason that people with a stored harvest live more securely and possess more leisure in the winter season.

BLOW-PIPE MARKSMEN. *One of the weapons used by the primitive hunters of south-eastern Asia is the blow-pipe, discharging a dart dipped in poison. Our photograph shows a Bornean marksman displaying his weapon —a tube seven feet long—to a group of admiring youths.*

HUNTING IN THE ARCTIC. The Eskimo inhabiting the Arctic coastal fringe from Alaska to Newfoundland are almost entirely dependent on fish for their sustenance. Here we see a native woman, cosily encased in thick furs, fishing through a hole broken in the ice.

Of the higher grade hunters, the best example is that of the North American Indian of the Plains. For countless centuries anterior to the coming of the white man to the New World, these tribes lived by hunting the buffalo. Following the ceaseless movements of the herds as they searched for fresh pastures, the Plains Indian could not build a permanent home, or make and carry fine pottery or other utensils; he employed his artistic skill in the manufacture and adornment of beautiful leather clothes, personal ornaments, and good weapons. His agricultural ability was limited to cultivation (with the hoe) of maize, a crop grown and harvested within a few months, fit for long storage and none the worse for rough transport. With the introduction of the horse many American tribes abandoned even this simple culture of maize, for now the buffalo was followed with rapidity, and the horse, as well, could be utilized—every scrap of the dead animal was put to some purpose.

The hardy life of a buffalo hunter, his need for resource and skill, led to the exaltation of physical fitness; lads were trained to sink individuality in the common aim of the tribe, while manliness and loyal cooperation became the most admired qualities. The climate did not permit the Plains folk to preserve meat, as the tribes of Northern Canada stored the flesh of the caribou deer in the form called 'pemmican', or as the Haida stored salmon roes. This food would be as little relished by most Europeans as the century-old eggs of the Chinese, or the bog-soaked butter of the Irish, for the roes were buried until putrid, and then dug up and eaten with aromatic berries.

Not only the Haida, but all the north-west coast of America provides examples of native folk in a state of transition; they were—and in the far north, still are—great hunters, taking vast quantities of fish, particularly salmon and halibut, for storage, and also collecting berries and nuts. Houses were permanent, arts and crafts developed during the enforced leisure of long winters. The Eskimo, in particular, hunters of polar bear, and especially seal, evolved a highly specialized culture with no absolute parallel. Apart from modern imports, the Eskimo live upon animal products, with seal meat as the mainstay of existence; no fruit, grain or vegetable has a place in the traditional menu of the Eskimo. The Lapps, too, inhabiting the Arctic fringe of north-west Europe, depend almost entirely upon the meat of reindeer, which they drive in enormous herds about the highlands in summer and the sheltered valleys in the winter.

Coming of Agriculture. Cultivation of the soil, with consequent development of agricultural implements, the working out of systems of crop rotation, and of the best yielding food plants, was evolved in regions where peace prevailed, and where food-giving forests or bountiful supplies of animals suitable for the pot did not exist. Whether they built houses that stand the test of time or not, the agricultural, settled folk dwelt in permanent societies, and among their ranks one finds (as in Egypt, Mexico and Peru) the famous makers of beautiful pottery, the weavers of fine textiles, and, often, the builders of great temples to the gods of Nature. Domestication of animals, when it accompanies the development of agriculture and horticulture, brings about the most settled life of all—that of the producer of what we may term tamed crops as well as tamed animals, for the unique purpose of supplying the food needs of the population. Much of the food which is derived from the vegetable kingdom can be eaten raw, but even amongst the humblest human collectors the preparation of food may be a lengthy and elaborate process. For instance, in Australia the seeds of the panicum grass, beaten into baskets with wicker ' paddles ' or shaken from the heads reaped with a stone knife, are ground on a flat stone.

The acorns, so important to many Californian tribes, were husked by the women with their teeth, pounded in stone mortars, and the resultant meal thoroughly rinsed in a sand-lined hollow in the ground to rid it of its bitter taste. Boiling, roasting or baking in a form of earth-oven produced a palatable dish from unpromising material.

Origin of the Cereal. To those peoples who had arrived at the domestication of food-plants, the cereals were the most important, and the Old World is richer in these than the New. For instance, there is wheat, prehistoric in Europe, and known to the ancient lake-dwellers, the Egyptians, and the ancient Chinese. Barley is amongst the earliest of cultivated plants. Oats are not so old; their origin seems to lie in the region extending from the north of Italy and Greece to Asia Minor. Millet, again, was cultivated from prehistoric times in southern Europe, Egypt and Asia. Durra (known also as Indian millet), indigenous in Africa, spread through all the equatorial region, and also to China. Rice had its home in China and India and spread to other lands of the Fast East. In the Dutch Indies, for instance, it forms a staple food and is stored in special buildings (*see* Colour Plate facing p. 32). Under intensive cultivation this cereal developed many varieties, each requiring different treatment. In the low countries one variety is germinated in nurseries; the young plants are transferred to artificial swamps, continuously irrigated by a system of canals. In the hills another variety, trained to require less moisture, is grown in terraces built on the hill-slopes.

It is now accepted that maize is definitely American in origin, although the parent plant from which it was produced is still a little doubtful. Possibly it is the teosinte, indigenous to the highlands of Guatemala and Mexico, which bears a few seeds and is the only plant which will cross with cultivated maize. At the time of the discovery of America there were over thirty varieties of maize cultivated in Peru, a fact which implies a long history behind the more highly developed American cultures. Probably it was domesticated by the very early Maya, and spread north and south. Certainly the development of the arts and crafts in America varied directly with the intensity of maize-cultivation, which provided growers with a settled and secure life.

The rapidity with which the maize-plant spread over the Old World after Columbus is a striking example of the fact that man never

ESKIMO ' DUCK DANCE.' Hunting provides the Eskimo of Greenland and North America with a much appreciated change of diet. Here a hunter is performing a dance surrounded by the victims of his bow, a procedure which reminds one of the hunter-artists of the Stone Age, who also performed ritual dances on their return from a successful foray in search of food.

neglects a good food-plant. Introduced on the West African coast, it had, within a century, become the staple food of half Africa, and its range was far in advance of European exploration. As regards Europe, it appears to have spread along the Mediterranean first. In Egypt it was known as 'Syrian durra'; in Turkey as 'Egyptian wheat'; in Germany as *Turkische Weisen*; in France, '*blé de Turquie*'; in India, 'Mecca millet'; and to us as 'Guinea corn,' because it came via the west coast of Africa. The other American cereal, the quinoa, a kind of buck-wheat, has the distinction of being able to grow at a higher altitude than any other; it was, with the potato, the principal vegetable food of the sparse population of the Peruvian and Bolivian highlands.

Removing the Husk. All cereals require preparation to remove the husk—whether by the treading-out process, performed by women, cattle or sheep, by the indigenous American system of soaking maize in lime-water, or by the Old-World inventions of the sledge and the flail. Then follows winnowing, which rids the seed of the husks. This can be performed laboriously by blowing from the mouth (as in Australia), or casting the trodden seed into the wind, or using a hand-fan, the prototype of the old English revolving winnowing-machine with its textile 'sails.' Next comes grinding, performed, for instance, in ancient America by means of a stone slab (known as *metate*) and a stone roller; or by pounding on a flat rock (as is done with the grass-seeds in Australia). The latter process, which would naturally tend to develop a hollow in the rock, no doubt gave rise to the idea of a portable mortar and pestle, which, made from wood, are found practically throughout Africa.

In Europe and the Mediterranean the grinding of seeds by one flat stone upon another gave rise to the idea of the rotary 'quern,' which is the prototype of the windmill; the quern itself probably dates as far back as the later Stone Age.

Edible Roots. Owing to climatic conditions, circumstances involved in migrations and quality of soil, cereals are not universally distributed; but their place is taken in wide areas, notably the forested regions of South America, south-eastern Asia and in the Pacific Islands, by certain roots and tubers.

Most interesting of these is the manioc (known also as mandioca, manihot, and, in its prepared form, as cassava), apparently indigenous in the forestal area of South America, and, like maize, now widespread in Africa. Most varieties of manioc are poisonous, owing to the presence of hydrocyanic acid in the juice of the root. The root is, therefore, first scraped with stone, sliced and grated on a board set with small stone chips. The gratings are washed in running water and packed in a basket-work squeezer, which expresses all the moisture: the paste is then ready for cooking. Toasting produces *farinha de mandioca*, the constant accompaniment of Brazilian meals, while granulation on hot plates produces tapioca. It is remarkable that primitive forest Indians should have evolved the process of eliminating a poisonous element from a root. The natural inference would be that the first experimentalists, finding the

WINNOWING BY WIND. *From earliest times Man has used the wind to separate the chaff from the threshed grain. These peasants in Kathiawar are using baskets as 'winnowing fans' virtually identical with those in use in Homeric times and in Egypt 3,000 years B.C.*

Photo, Major Meek

root poisonous, would have let it alone; but a parallel is provided by the Semang, primitive collectors in the Malay States, who wash out the poisonous element from certain yams, although they do not employ a squeezer. The Americans went still further. They collected the poisonous juice and boiled it. The deleterious acid volatilized, and the resultant liquor became the main flavouring of the famous West Indian pepper-pot stew, and can be bought under the name of *cassareep*.

The Potato. The potato is another gift from America, and appears to be indigenous to Chile. It belongs to the solanum family; its origin and history have been confused with those of the sweet potato (*batata*), which is the root of a variety of convolvulus; this was the ' potato ' first brought to Europe. In English literature the first references to the potato almost certainly refer to the batata, still procurable in London, though not popular. The introduction of the true potato, via Virginia, took place nearly a century after the discovery of America. The development of the many varieties of potato now cultivated in the Old World provides one of the most remarkable items in the history of cultivated plants.

The true potato was one of the staple foods of the South American highlands. It was exposed to frost, dried in the sun after pounding, and then stored in dark chambers in order to prevent it turning black. So stored it became a stodgy, odoriferous food, nutritious and suitable to altitude and climate.

In Indonesia and Oceania the *taro* was of great importance: it is the root of a species of arum. It was baked and pounded in rude trays with stone pestles. A dough was made with water, and then set aside to ferment. Four or five days brought it to its most esteemed condition. Wrapped in leaves and moistened with water when required, it provided a valuable supply of ' sea-stores ' to the Polynesians on their long and precarious voyages through the southern seas.

BREAD FROM POISONOUS ROOTS. *A principal food of the Amazon Indians is the manioc root after the hydrocyanic (prussic) acid which it contains has been squeezed out. The girls seen in this photograph are rasping the roots, after which the resulting meal is pressed into cakes and roasted.*

Photo, E.N.A.

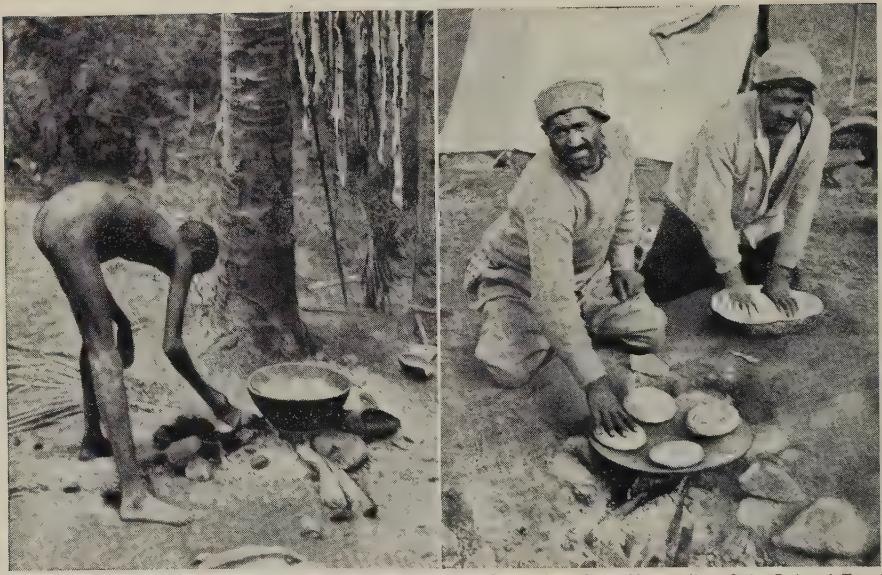
One other vegetable product requires mention, the pith of the sago-palm, which the natives of New Guinea and their immediate neighbours excavated from the split trunk by means of stone implements. This provides the sago of modern commerce. Coconut, banana, breadfruit, also belong to the Old World.

LESSON 17

Culinary Art of the Aboriginal

THOUGH much of man's food, animal as well as vegetable, can be eaten raw, the domestication of fire made an enormous difference to the amenities of human life.

The use of fire for preserving products is very ancient, and no tribe is known to history that has not utilized it. Its application to foodstuffs may have come from observation of the effect of the sun, especially in the dry tropics, upon flesh and fish. A process of preservation which enabled stocks of perishable materials to be stored against future contingencies was of vital importance. Fire heat and fire smoke were probably adopted as substitutes for the sun; experiment showed that the quality of the product depends much on the smoke. No one would like to eat a kipper smoked over a soft coal fire. Oak chips produce a pleasing result, but mahogany is infinitely superior.



PRIMITIVE COOKS AND DISHES. The left-hand photo is of a native of the Nuer tribe of the Bahr el Zeraf district in the region of the Upper Nile, cooking crocodile flesh in a clay vessel set on a pile of smouldering chips and heated stones. Right, Dards—inhabitants of the western Himalayan state of Hunza—baking chupattis, i.e. unleavened cakes of wheaten flour, the native form of bread.

Photo, Mondiale

Preserved meat and fish, prepared by such simple methods, provided sustenance for many primitive tribes. When pounded to a paste and mixed with fat, meat becomes the ' pemmican ' of North America, which has been the stand-by of many modern Polar expeditions. The buccaneers, who played so picturesque a part in the history of American colonization, were originally *boucaniers*, men who rounded up the half-wild cattle introduced by the early explorers, and made a living by smoking the flesh on a wooden frame, called *boucan.*

Given the use of fire, a number of developments arise naturally. The savoury smell produced suggests light cooking, broiling or toasting of viands needed for immediate consumption. Provided that the right fuel is used, there is no better method for preparing meat. Those who have eaten steaks of freshly-killed mutton, cooked by the Pueblo Indians simply by throwing them into the glowing ashes of a juniper fire, will know how true this statement is. The lump of meat comes out looking charred and disreputable, but the inside is juicy and tender; the modicum of juniper ash, which adheres after resolute brushing, adds to the flavour. Methods like these are practically worldwide, but there are other, rather more specialized, processes which are of local invention. For instance, the Coconino Indians of Arizona used to put bits of meat, crickets and so forth with glowing embers into a clay-lined basket and shake the collection together. This embryo form of hearth may have been one of the inventions which led to the further development of pottery. The basket would, in the course of time, decay and the fire-hardened lining remain as a bowl.

Grilling maize-cakes on plates of stone or pottery was not uncommon in America, from Mexico to Venezuela and the Guianas. These plates were used exactly as a metal ' girdle ' or ' griddle ' in Great Britain. The plate is heated and a thin layer of maize paste poured on, which is immediately peeled off as a wafer. The wafers, thin as the finest tissue paper, are arranged in a pile; a handful, broken from the sides, provides a crisp adjunct to a meal. In particular, the Pueblo Indians of Zuni, on the borders of Arizona and New Mexico, are experts at making these wafers.

Boiling and Steaming. The use of water in cooking, the process of boiling and steaming, can only be developed to a high degree by tribes who have arrived at the art of pottery-making. A basket obviously cannot be put on the fire, nor a wooden vessel. Yet water can be raised to boiling point in receptacles which are not fireproof. Certain tribes, particularly those of California, as well as of Polynesia, where pottery is unknown, have developed the technique of basketwork to such a closeness that it is watertight. Water is brought to the boil simply by throwing stones into it, after they have been heated almost to redness in the fire. The same process is employed by some of the tribes of the north-west coast of America, but here the vessels are of wood.

Even the method of cooking by steam has its prototype among one of the most backward races. The Andamanese certainly within historical knowledge used and controlled fire, but they had no method of producing it. Nevertheless, they had discovered the principle of modern 'paper-bag' cookery; more than that, they invented the prototype of the high-pressure steam cooker, of which several patterns have appeared on the English market in recent years. A joint of large bamboo was cut, stopped at one end by its natural node. This was filled with the food to be cooked, chiefly meat or fish, and a little water added. The open end was then tightly plugged with leaves, and the bamboo vessel was placed on an open fire. Bamboo, owing to the hardness of its rind, which contains a high proportion of silica, is not readily combustible; it will withstand the action of a low fire for some time. After the appropriate period, the bamboo cylinder was taken off, left to cool and then split open with a stone axe. The meal, piping hot, would be found perfectly cooked.

Primitive Ovens. More elaborate was the method practised in Polynesia and in certain parts of Melanesia. This was on a far larger scale, employed in big communal feasts as well as for family use. A pit was dug of a size to fit the purpose, and a fire built inside. On this were piled large stones, which rapidly became hot. Packets of food, vegetable and animal, wrapped in fresh pandanus leaves, were placed on the stones when the fire had died down; layers of leaves were added, and then a thick coating of earth, well trodden in. The stifled heat, acting on the juicy leaves, produced steam in a certain degree of compression; when in the course of an hour or two the primitive 'oven' was opened, meat and vegetables were as savoury as a chef could render them.

The dry oven, erected above ground, whereby a baking process is obtained, appears later in human history, because it involves stone building. In such cases the beehive-like structure is heated by a wood fire lighted within. The ashes are then raked out and the object to be cooked, mostly some sort of dough, inserted. Such is the process amongst the Pueblo Indians, but it is used for wheat-bread and was introduced from Mexico. It is probably the result of contact with Europeans, although it may possibly have been developed from the indigenous form of Aztec 'Turkish bath,' where the patient sat in a small enclosed masonry chamber over hot stones on which water was poured.

LESSON 18

Use of Stimulants and Narcotics

MAN has never been satisfied with food and drink simply as nourishment. He has sought condiments to improve the flavour of his viands, and has discovered many accessories, desirable from their taste or from the exhilarating effect which they produce.

Importance of Salt. Salt is the most widespread example of a condiment; the craving for it is clearly marked amongst the lower mammalia, especially those of herbivorous habits. Amongst the human fraternity, the control of natural salt deposits has had a definite effect on migrations, as in West Africa. Amongst inland tribes, far from any natural source of supply, salt has become a valuable form of currency (notably in the Kasai and Kwilu regions of the Belgian Congo). Here salt, of a kind, is manufactured. Marsh plants are burned, and the ashes packed into basket-work filters. Water is strained through these, then evaporated in vessels of pottery or banana-leaf. The result is an extremely impure form of crystalline salt, which it is best for the unacclimatized European to avoid.

Areca Nut. More stimulating is the areca nut, the use of which is widespread throughout India, Ceylon, Indonesia, New Guinea and Melanesia. Usually the nut is wrapped in a leaf of the betel pepper tree and a dab of lime added to give a sting to the flavour.

ONE OF OPIUM'S VICTIMS. At first the opium addict experiences a pleasurable excitement and sense of well-being, but depression soon follows, and then more opium is generally taken in the hope of restoring the former condition. When the habit has been definitely acquired, the complexion of the opium-smoker turns sallow, he suffers from sleeplessness and sometimes sickness, and emaciation gradually supervenes. A mere wreck of his former self, he sinks through the various stages of degradation until he dies from exhaustion. This photograph is of one of the inmates of a Javan opium den, lying on the couch where he passes his drugged existence.

Photo, O. Kurkdjian

The whole is placed in the mouth and chewed. Special knives for slicing the nut, receptacles for the lime, in silver, cane or gourd, lime-spoons (spatulate in shape), and even mortars in which the nut is pounded by the aged and toothless, are common objects in museums. Popularly, the habit has come to be known as betel nut chewing, but this is a misnomer, because the nut is the produce of the Areca palm.

Even the very primitive Australians had their stimulant, *pituri*, the product of a plant known as *Duboisia hopwoodii.* The product, described as ' half-green, half-yellow tea, with plenty of chips in it,' gave rise to practically the only commerce known to the aborigines. Messengers were sent many miles to obtain a supply in exchange for weapons and utensils. The ' tea ' was roasted in the camp-fire, crushed in the fingers and the larger chips removed. Ashes of acacia leaves were added, and the mixture worked up into ' quids ' for chewing.

Cocaine. In South America, especially amongst the tribes of the upper slopes of the Andes (Peru and Bolivia), a practice analogous to the ' betel chewing ' of Asia and Melanesia had been developed in the days before the Spanish conquest. The main ingredient in this case was the leaf of the coca, also flavoured with lime. Among the many drugs which have come from America to Europe, few have been more valuable, or more deleterious, than cocaine, which is the extract of this leaf. The amount of absolute cocaine in a coca-leaf is minute; even continuous chewing can do no great harm. It had a great use in the high altitudes of the Andes, because it allayed mountain sickness and the pangs of hunger; therefore mountaineers carrying heavy burdens could undertake long journeys with no more provision than a bag of the leaves and a gourd of lime. The chewing of tobacco, yet another American product, seems to be a later development of the use of the plant, which, in the country of its origin, was invariably inhaled.

Far more violent are the effects of certain cacti and fungi, well known to a few North American peoples and to some tribes in the forested area of South America. Many of these varieties have not been analysed, since they are generally associated with some form of ' secret society ' and are not easy to obtain. Most of them produce a narcotic state, accompanied by vivid dream visions. The best-known is the peyote, a variety of cactus found chiefly in the region of the Rio Grande in North America. It is regarded as a remedy for all ills, but is also the object of a particular cult, the members of which meet and jointly partake of the narcotic, enjoying their highly coloured visions, which are regarded as partly prophetic. It has been said by Europeans who have had the experience that there are no ill after-effects.

Opium. The same cannot be said of opium or of hashish. Opium is the product of the poppy and has been known to the East from very early times. Taken by the mouth in moderation by a people who have become accustomed to it, it is a sedative, a soporific, and also a febrifuge. It is a valuable drug in Western pharmacy, when administered under medical advice, but when smoked and inhaled it becomes a progressive poison.

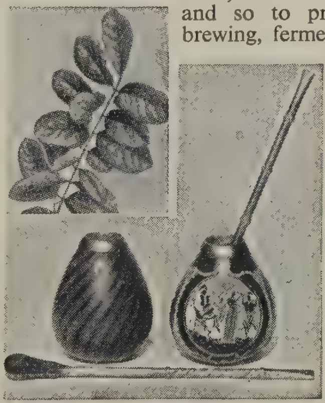
Hashish, a preparation of Indian hemp (*Cannabis indica*), belongs to the nearer East;

it has spread through Africa as far as Arab influence has penetrated. This can, like opium, be taken either by the mouth or inhaled in smoke. The effect produced is a vision of brilliant colour, and, on waking, an extraordinary prolongation of time and space. It is a dangerous drug because, as with cocaine, morphine (a product of opium) and inhaled opium, the doses have to be increased progressively to produce the required result.

Tea and Coffee. Many peoples have discovered that certain vegetable products, by infusion in boiling water, provide an extract which is not only pleasant but stimulating. Perhaps tea provides the best example. The tea plant appears to be indigenous to India and to have spread very rapidly to China. The particular drug extracted by boiling is known as theine; it is a sedative, but does not combine comfortably with meat in the human interior. It has a ' tanning ' effect, which renders meat indigestible. It was developed in countries where the main diet was farinaceous (rice) and taken only as a weak infusion.

Coffee differs. Its original home was Arabia and Abyssinia; the basic drug which it contains is caffeine, a valuable heart stimulant, but apt to induce insomnia if taken in large quantities. It is thus useful for those who have to do an all-night job under emergency.

Paraguayan Maté. But for meat-eating tribes the best beverage of this type appears to be maté, an infusion of the leaves of a Paraguayan shrub, discovered by the early Jesuits, and now prevalent practically throughout the whole of the plains of South America. It was introduced into England during the Great War of 1914–18. Discovered in the early days of exploration, it was developed in Brazil; containing no tannin, it can be taken with meat and became the chief beverage of the cattle-keeping population of South America. Both digestible and sustaining, it is far better for the meat-eaters of Europe than tea.



MATÉ. Gourds for holding the liquid tea, and bombillas through which it is sipped. Top, left, the leaves of the plant.

The question of appropriate diet is, amongst primitive peoples, a matter of great importance. The Masai of East Africa take an emetic between animal and vegetable food.

Stimulating beverages, derived from the fermentation of a number of products, mainly vegetable, are widespread amongst human races which have advanced so far that their economic life is based partly or wholly on cultivation. Fermentation produces alcohol, and the alcohol provides the stimulant, often with narcotic effects.

Fermented Drinks. The origin of fermented drinks is obscure, because the materials are so varied according to the environment. Wine is a good example. The wine-grape appears to be indigenous in western Asia, the Caspian region and northern Africa, but one of the earliest instances of the use of fermented grape-juice comes from Persia in the form of a legend. A certain king, who had a great fondness for grapes, ordered a large quantity to be stored in jars for the winter season. These, opened when fermentation had set in, were so distasteful that he had them labelled ' poison ' and forgot them. A year later, the lady who had been the ' light of the harem ' was deposed in favour of a younger rival. She discovered the jars, with label. Thinking that there was nothing left for her in life, she took a long drink. By this time fermentation was complete, the wine had matured. The experience not only reconciled her to existence on this earth, but, when the liquor was tactfully introduced to the potentate, resulted in her reinstallation as favourite.

All cereals, especially when the grains are sprouting, will produce a form of beer, if the meal, mixed with water, is allowed to ferment and so to produce alcohol. In modern brewing, fermentation is encouraged by the admixture of yeast, but amongst primitive tribes the process was hastened by human saliva. In Africa, maize beer is induced to ferment quickly by the maker chewing a few grains and spitting them into the mixture of maize meal and water. Maize was introduced into Africa from America, where the process was originally observed.

In Polynesia, where no cereals are grown, the intoxicating drink was kaya, prepared from the root of *Piper methysticum*, a kind of wild ginger. The root was chewed by young girls, then mixed with water. The resulting intoxicating drink was extremely stimulating to conversation, but in excess, very detrimental to locomotion.

Ancient America, apart from the various fungi, had its stimulant in the form of the juice of the agave (Mexican aloe). If the heart of this variety of cactus is cut out, the juice can be extracted and provides a harmless drink, but if it is allowed to ferment it becomes extremely potent. In Aztec days the fermented beverage was known as octli, now called pulque, from a Spanish word. But there were severe restrictions regarding the drinking of octli under the Aztec regime; it was permitted only to people who had reached a mature age.

In Africa, apart from the mild beers based on millet and maize, prepared as already described, there is also the sap of certain palm trees, used widely in the Congo area, mainly the raphia and the elais. The fresh sap is harmless but, if it is left to ferment, it becomes an intoxicating drink with heavy alcoholic content.

WOMAN SMOKER OF THE EAST. *Tobacco was introduced into China in the 16th century, and all classes and both sexes are greatly given to smoking. This old peasant-woman is smoking a water-pipe.*

Photo, B. T. Prideaux

Distilled Drink. So far we have been considering fermented drinks produced without apparatus. But there is another means of producing intoxicants; the alcohol may be extracted from any vegetable product by distillation. Alcohol volatilizes (i.e becomes vapour) before water boils. Rotting cabbage stalks, enclosed in a kettle, with a length of hosepipe, cooled by water, will drip alcohol before the steam is generated. But alcohol, so produced, is definitely poisonous. It requires at least three years to mature. Distillation is not known to primitive peoples, apart from European contact. The Japanese spirit, saki, produced from rice, can hardly be regarded as ' primitive.'

Origin of Smoking. There remains the question of inhaling, which is closely connected with tobacco. As far as available evidence goes, tobacco was unknown in the Old World before the discovery of America. But, it spread so rapidly through Europe and Africa that its origin was obscured.

The inhalation of fumes produced by aromatic plants may have been practised in the Old World before Columbus, but the tobacco plant is definitely American. In America its use was, in the main, ceremonial. In Central America it was made into cigar form, and smoked through a tube. Columbus misunderstood the word ' tabaco,' which was the name of the tube in which the leaf was smoked. Among the North American Indians (and later in the Paraguayan region), it was smoked in pipes. But the use of tobacco in the Americas was in the main that of a drug which, by inhalation, produced a comatose condition during which certain visions appeared, regarded as prophetic revelations. When introduced into Africa, the phrase used for smoking was ' drinking ' tobacco—that is, inhalation. Inhalation also occurs in the Farther East, where, in Upper Burma and China, women smoke tobacco in a water-pipe and men use the water, impregnated with tobacco, as a form of liquid snuff.

Opium, the product of the poppy, has spread from Farther Asia, in its inhaling form, through Africa where Arab influence has penetrated; also hashish, *Cannabis indica*. Both of these drugs can be smoked or inhaled, with dream visions as a result.

Inhalation of dry soporifics has its origin in the sniffing of tobacco powder or tobacco water. The final and most damaging drug, taken through the nose, is cocaine powder, an American product in its origin, which has a progressive deleterious effect on the human nervous organization.

LESSON 19

The Primitive Craft of Pottery

POTTERY in the main, as a craft, demands two conditions: the presence of suitable clays, and settled life based on agriculture in some form. It is hardly ever found among nomadic tribes or even among semi-nomadic, because its fragility renders it unfavourable for constant transport. The vessels of the nomads and semi-nomads are, for obvious reasons, of less breakable materials, such as basketwork, hide, wood and stone. In the region of the Arctic and in many coral islands of the Pacific, suitable clay does not exist. Thus pottery, except as an intrusive product in modern times, can be regarded, for the purpose of this Lesson, as non-existent in the Arctic, the north-west coast of America and California, the Antarctic, Polynesia, and among the purely nomadic tribes of the Old World.

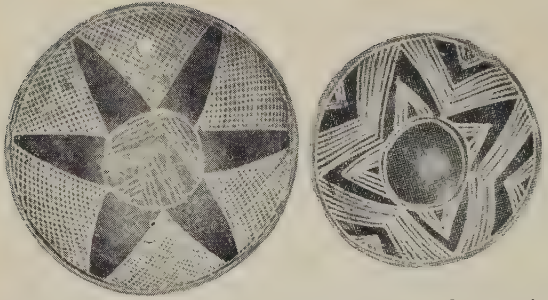
The distribution of different forms of clay is widespread. The material consists of a mixture of various silicates, that of aluminium predominating, usually in combination with iron. The presence of iron in the clay has a definite effect upon the colour of the ware when subjected to the action of fire. Firing at a low temperature produces a black oxide, but a higher temperature produces red. In the obscure jargon employed by the early alchemists, ' the black crows leave the nest.'

The Early Potter's Difficulties. Now the process of making a pottery vessel is complicated. It is not simply the digging of clay, making a shape with the fingers and putting the formed object in a fire. Such a method is doomed to failure, because there is one great enemy of the primitive potter—steam. Clay contains water of two kinds—' admixed ' and ' chemically combined.' Each of these, under the effect of heat, generates steam and may crack the pot. The admixed water is necessary to the potter because it gives the clay its plasticity, but in the actual process of moulding much kneading is essential in order to express it in a pap-like condition. Further, some ' tempering ' material must be added, in order to absorb the admixed water and also the steam given off by the chemically combined water. Sand is useful for this purpose, but the pulverized shreds of old broken pots already subjected to fire are better, because clay so tempered can be exposed to a hot sun and will provide a solid vessel or brick which will withstand a certain amount of rainfall. The granaries of northern Africa and the ' adobe ' buildings of the Pueblo region of North America provide examples; sun-dried clay can be broken up, mixed with water and reduced again to a plastic state. This is not possible with pottery which has been ' fired ' because the process of firing expels the chemically combined water, without which pottery cannot return to clay. Thus the pulverized shreds of old pots, containing no water, loosen the texture of new clay and allow for the escape of steam generated in the firing of a new vessel.

Primitive pottery has been a most important factor in archaeological study, as will be seen from our Course in Archaeology (Vol. I). The pot itself is very perishable, because it is so easily broken, but the fragments will survive for centuries, even buried in damp earth. During investigations of the cultural history of long occupied sites, the styles of pottery fragments discovered at different levels of excavation have provided one of the best means of dating and indicating connexion with other cultural centres.

Pottery, whether sun-baked or fired, has served for innumerable purposes apart from domestic uses: it has been fashioned into burial urns, musical instruments, pipes, toys, religious effigies, and so forth; but, from the economic point of view, perhaps its most important function is that relating to cookery.

Influence of Basket Making. The origin of pottery is a matter upon which it is impossible to dogmatize, but there is no doubt that it is intimately connected with basketwork in many areas. Shapes natural only to textile processes occur in nearly all phases of pottery making. In various regions of the world—for instance, the Kasai district of the Belgian Congo and the Guianas of South America—the painted ornament on pottery shows the geometrical angularity which is characteristic of basketwork. The basket-maker cannot produce a curve; straight lines, diagonals and ' stepped ' patterns are his limit, while ' free-hand ' painting belongs to more advanced cultures, so far as pottery is concerned. But even in such cases the dominance of textile motives is still sufficiently apparent to suggest the influence of the parent industry.



POTTERY AND BASKETWARE. *Although the origin of pottery is uncertain, much of the evidence suggests a close connexion with basketwork. The pottery bowls illustrated above, for instance, relics of the Amratian culture of ancient Egypt, are decorated with basketwork designs.*

Some definite evidence is supplied by fragments of pottery from North America. To quote from Squier and Davis:

> In the construction of pots of large size in the Mississippi valley, it was customary to make models in baskets of willow or splints, which, at the proper period, were burnt off, leaving the vessel perfect in form and retaining the somewhat ornamental markings of their moulds. Some of them, found on the Ohio, seem to have been modelled [moulded] in bags or netting of coarse thread or twisted bark.

Castings taken from fragments of this description have shed much light on primitive weaving, Again, the lining of baskets with clay, as occurs, for instance, in the cooking appliances of the Coconino Indians of America, and the 'dice-boxes' of the natives of the African Kwilu, might well suggest the use of clay as a material for a vessel, when the outer covering of textile decayed, but the clay lining survived, with the imprint of the textile on its outer surface. It is at least possible, then, that pottery is an accidental development of the basket-maker's craft.

The Potter's Wheel. Pottery falls into two classes, hand-made and wheel-made. The invention of the potter's wheel belongs to the Old World. This appliance was certainly not known in the Americas before Columbus. Probably the earliest wheel-made pottery is that of Mesopotamia, dating to about 3000 B.C., and the mechanical contrivance seems to have spread eastward to China and south and west to Egypt and the Mediterranean.

The invention of the free-running wheel marked an epoch in ceramic art. Not only does the running wheel bring every part of the embryo pot into rapid contact with the hand of the modeller, but its centrifugal action works on the plastic clay. Production becomes more rapid, technique improves, but forms become more mechanically regular, losing much of the charm which the potter, for instance, of ancient Peru could give to his material without mechanical assistance. It is a question of the artist becoming, literally, more 'out of touch' with his material. It is with the more primitive methods of pottery, however, that we are here concerned.

Moulding. This may be the earliest process, the prepared clay being plastered in the interior of a basket and the textile burnt off in the firing process. The early prehistoric ware of the Mississippi valley provides an excellent example. Sometimes the clay may be moulded over a rounded object, such as an old pot or a gourd (Africa), the internal mould being extracted later, or left to destruction in the firing process, according to its nature. Necked vessels are generally made in two halves and joined up; this process is known as building. True pottery moulds, capable of repeated use, were employed in pre-conquest America from Maya and pre-Inca times, but, even in this more highly developed process, details such

EARLY POTTERY. *Left, Peruvian two-spouted water bottle with coloured bird motif. Above, tripod bowl in the early Maya style. Both are hand-made.*

British Museum and 'The Studio'

as handles and necks were modelled separately and added by the building process.

Technique of Modelling. Modelling, whereby the pot is made simply with the fingers, is common in Africa and was common in ancient America; it presents several techniques. A lump of clay may be taken, a hole punched in the middle, and the sides gradually thinned by gentle stroking upwards, one hand inside, the other outside, pieces of gourd being used as scrapers (especially in Africa). Sometimes the pot is modelled from the mouth downwards, as amongst the Kikuyu, the bottom being added as a separate piece (as was done by the Naga tribes of Assam).

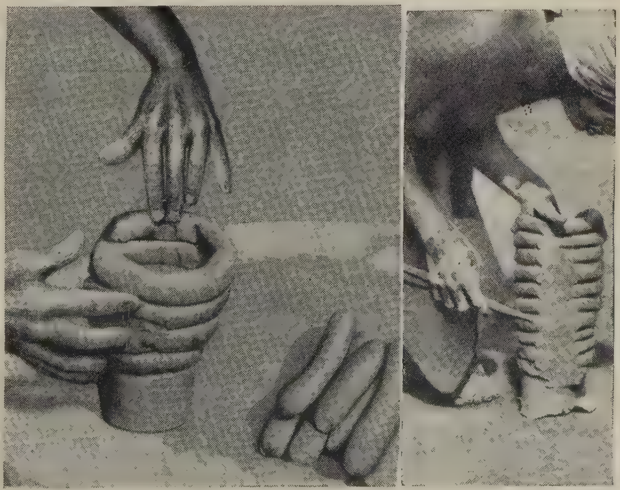
Coiling Process. But the finest pottery made by primitive man, without the wheel, is the result of the coiling process, which alone, under expert fingers, ensures uniform thickness to the walls of the vessel, thus providing against splitting under the action of fire. This process is not uncommon in Africa, but attained its perfection in ancient America. There are still elderly women among the Pueblo tribes of Arizona and New Mexico who are adepts. This process, freely used by the ancient Maya and Peruvians (who produced the finest hand-made pottery in the world), merits description from an eye-witness.

A small lump of clay, modelled with the fingers into a saucer, which provides the base of the pot, is placed in a dish; another lump of clay is rolled into 'sausage' form, patted flat into the form of a 'ribbon,' and incorporated in the edge of the saucer. Additional 'ribbons,' applied in spiral form, gradually build up a pot of uniform thickness; continual scraping, inside and out, assists in keeping the walls to a uniform quality. The pot is left to dry in the sun; it is burnished with a rounded pebble, to smooth the surface and close the pores of the clay. Then comes the decoration and, finally, the firing. The illustrations show this method as practised by the natives of West Africa.

Decorative Processes. Decoration of pottery can be provided by many processes. Vases moulded in basketwork carry with them the impression of the mould; this is often reproduced in paint, as in British Guiana and ancient Peru. Pottery moulds can, naturally, be prepared to give a decorative design, as amongst the early Maya. Artistic designs can be produced by means of wooden or pottery stamps (Africa and America), or by means of *roulettes.* The latter are small cylinders of pottery (America) or string-work (Africa), rolled over the surface of the clay when still in a plastic condition. The ancient Americans went even further. Many of their finest vases were carved with designs when half sun-dried, or sometimes engraved after firing.

Colour decoration requires different treatment. After sun-drying, a solution of various clays can be added (known as a 'slip') which will, according to the variety of clay, fire in colours usually quite different from the colour of the slip when first applied. The successful handling of slip decoration implies long experiment, and it is a fact that a greater variety of colour is found in the pottery of the Nasca valley in southern Peru (about 200 B.C. to A.D. 200) than anywhere else.

To judge from the process of the old Pueblo potters, certain clays, known to pro-



POTTERY TECHNIQUE. Many living races make their pottery after the primitive fashion followed by this native of Sierra Leone. Clay 'sausages' are prepared and built up on a solid base (left). When the required height is reached the outside of the vessel is scraped smooth with a stick (right). There remains the formation of neck and spout, and baking in a kiln completes the process.

Photos, Northcote Thomas

duce certain colours under the effect of fire, are pounded with water and reduced to the consistency of cream. Amongst the Zuni the whole pot, sun-dried, is coated with white. Outlines in black are drawn freehand with a brush made from a strip of aloe-leaf, which has been chewed at one end to release the fibre. Red is added (which appears as a yellow), and then the pot is fired. Amongst the Zuni each pot is fired separately, surrounded by a circular construction of dung-cakes. In Africa wood alone is used. But the pureness of the white in Peruvian painted pottery suggests some fuel less smoky than wood; also, the quality of the firing implies a higher temperature than wood could supply.

Black pottery is found in prehistoric Egyptian sites as a broad black band round the mouths of red-ware beakers. It occurs in East and West Africa; also in the Northern district of the Peruvian coast (in the latter part of the period preceding conquest by the Spaniards).

These black wares of different regions are not the result of the same process. The black pottery of Uganda is due to the application of a plumbago slip. In West Africa black ware is produced by rolling the newly-fired pot in damp leaves, whereby the carbonization of the vegetable material is absorbed by the almost incandescent pot. As regards pre-dynastic Egypt, the pots were probably fired face downwards; the mouths became buried in ashes, so that the heat was not great enough to convert the black oxide of iron into the red oxide. The black Peruvian ware is a problem. There is no definite sign of a slip; it appears likely that the potters had discovered the West African method.

LESSON 20

The Beginnings of Writing

WITH the growth of human society, men found the need for communicating one with another by methods which provided a farther range than the voice, or which ensured greater privacy. Gesture, perhaps the simplest and most obvious method, became highly developed among certain hunting tribes, to whom silence in the organized pursuit of game was necessary, The Indians of the North American plains provide an excellent instance. As language developed, a natural relationship was established between words and material objects. For example, the Maori weaver, working on the coloured border of a cloak, sang a chant appropriate to the rhythm of the pattern. These chants became stereotyped to such an extent that, if the weaver made a mistake in a word, the pattern had to be unpicked and started all over again. The song gave a magical value to the pattern, but the pattern, conversely, formed a ‘ record ’ of the song; thus the necessity for recording provided another base for writing.

Primitive ‘Memory Ticklers.’ Among the aboriginal Australians a messenger would make certain marks on a short stick while he was receiving his message. On arriving at his destination these marks recalled to him the message, but it is very doubtful whether they could be interpreted by anyone else, any more than the meaning of a knot in a handkerchief can be elucidated by anyone except the person who tied it. The system had not become organized.

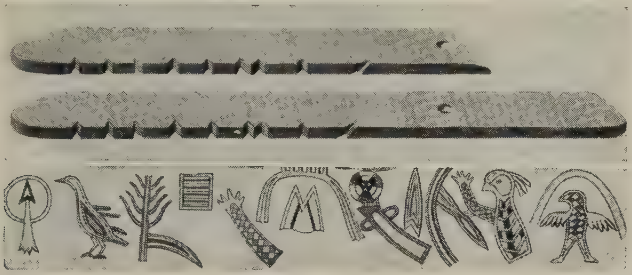
Tallies provide another form of record. A shepherd amongst the Pueblo Indians will cut a notch on his staff for every night that he is out in the desert, so that he knows when his term of duty is over. An elaboration of this simple proceeding was next applied to commerce. Notches of varying depth made in a stick represented quantities of goods delivered or monetary sums due. The stick was then split, each party to the bargain keeping half as a record. The final union of the two halves in the hands of one of the parties represented the settlement of the account. Tally-sticks were used by the British Exchequer down to the 19th century, and in country districts, notably hopfields, until almost the present day.

Another form of record is the owner's mark, some simple design cut, for instance, on an arrow. Amongst hunting tribes, living under Stone Age conditions, the making of an arrow was a laborious process, and arrows were valuable property. Moreover, especially in North America, the meat was divided according to the position of the arrows in the beast slain, and it was necessary to identify the owner. The marks were the equivalent of a cattle-brand.

Symbolic Messages. Then there is the later systematized association of ideas with objects, resulting in the symbolic message.

For instance, amongst the Malays, salt = love, pepper = hate, betel = jealousy. Parallels can be found all over the globe. Examples taken at random include the elaborate symbolic messages of West Africa, the 'language of flowers' popular in Victorian times, and even the green, yellow and red traffic lights of modern life,

The origin of modern writing, however, lies more in the picture than in anything else. The Eskimo and the Indians of North America generally recorded events, mostly hunting and war episodes, as pictures carved on bone or painted on hide. Gesture language played a part in this, because the figure of a man making a certain gesture conveyed the appropriate meaning. Symbolism naturally enters largely into the development of pictographic script; thus a tortoise may be taken as the representative of the earth, or a variety of bird to indicate a man of that name. From this stage, the ideographic, evolves the phonetic, in which pictures of objects, selected from the sound of their names, are grouped to form another word. This is, in fact, the rebus. Thus, the name of the Aztec ruler Itzcoatl appears on Mexican MSS. as a snake (coatl) bristling with blades of obsidian (itzli).

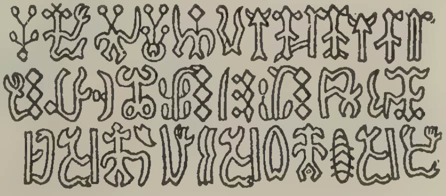

RUDIMENTARY WRITING. *These illustrations represent two of the earliest stages in writing. Top, notched sticks or tallies, used up to 1826 for keeping accounts in the Palace of Westminster. Below, an example of Red Indian pictographic script.*

From Faulman 'Geschichte der Schrift'

Origin of Letters. Development from this point may be comparatively rapid in the direction of an alphabet. Some object used to represent a syllable becomes a consonant or a vowel; for ease of writing, this becomes simplified in form and ends up as a 'letter,' The best example in which the changes can be observed is presented by the Egyptian script. The pictures of the early hieroglyphic script, already syllabic, were modified into the more cursive hieratic, and then into the simpler and still more cursive demotic scripts. Assyrian cuneiform and Chinese are, again, simplified pictures; the origin of many of the characters is revealed by their earliest forms. Even the Greek and Roman alphabets can be traced back to the pictograph.

In Peru, in Inca times, there existed a kind of record in the form of a series of knotted cords, known as 'quippu.' The position of each knot (*see* page 2) gave its position as a unit, ten or hundred, while the pattern of the knot indicated the numeral. A 'master-string' indicated the sum of the whole bunch. By this means the accounts of the empire of the Inca, extending over some 40 degrees of latitude, were recorded, and if we accept the statement of Garcilaso de la Vega, son of the daughter of a reigning Inca, events were also recorded by this method. Otherwise, in America, apart from pictographs, writing was only known to the ancient Maya of Central America (who had a semi-syllabic hieroglyphic form of script) and in the later Aztec rebus.

West Africa developed an alphabet of its own, inspired by European influence, but this was soon extinguished by Arabic; even the conventionalized records of the Nigerians, known as *n'sibidi*, became submerged. Oceania has no writing, properly so-called, apart from the seeming hieroglyphics peculiar to Easter Island. Here is a definite script, with no relation to Sumatra (the nearest island to the west with a 'writing') and no relation to South America on the east (2,000 miles away), where there was no writing at all. The script of Easter Island, a specimen of which from one of the stones is given below, remains a mystery, because the old interpreters passed away without revealing their secret.


MYSTERIOUS SCRIPT *of Easter Island which still defies translation.*

LESSON 21

Metallurgy of Primitive Men

MAN was by no means a savage when the use of metals was discovered. The people of Neolithic culture in Europe and Egypt were by then accomplished potters, weavers and stone-carvers; they had domesticated various cereals and certain animals. The same can be said of the American population of Central America and Peru. In Polynesia navigation had been developed under Stone Age conditions. But the discovery of methods of handling metal produced a great effect on human economics. It is strange to reflect that the Metal Age, up to the present, represents, in time, no more than one per cent of the Stone Age.

Somewhat capriciously distributed, metals occur in the form of ores as well as in their metallic form. Gold, copper, silver and iron appear, locally, in metallic form, and were worked by Stone Age methods in the beginning. But it was the discovery of the processes, first of melting, then of smelting, which gave metals in abundance to man.

It is possible that gold, which is fairly evenly distributed in its metallic form over the globe, particularly in river-beds, was the first metal used by man. It has the quality of fine colour and does not corrode. But it is useless as a tool, because it cannot take an edge. Copper marks the beginning of every early metal culture, and hammered copper has been found in Chaldean graves of the 5th millennium B.C. Lake Superior and the Coppermine river in the Arctic provided deposits of practically pure copper, and these were worked by the Eskimo and the Plains Indians simply by hammering. But while hammering will produce an edge of a kind on copper, too much hammering renders the tool brittle, and stone can be more easily carved with stone than with copper.

Iron, though susceptible to rust, provides man with the most competent edged tool. But iron, in metallic form, is known only in Ovifak in Greenland, where the Eskimo hammered out blades long before the coming of the white man. This statement refers to metallic iron belonging to our globe. Meteoric iron is more widely distributed, but the supply is sporadic and limited; it is confined to the Americas and to certain districts in Asia. The story of the 'Swords from Heaven' carried by Timur and Attila suggests that they were meteoric iron.

It is strange that the reduction of metal from ores should not have been discovered earlier in human history, because the oxide ores of the useful metals occur on the surface of the ground, and are easily reducible even by a casual camp-fire—especially the iron oxides, which are widely distributed.

But, once discovered, possibly independently in the Old World and the New, the process of smelting was invented. The ore, interlaid with fuel, was packed into a furnace, usually built of clay; in South Africa an ant-heap provided a convenient building. In ancient Peru, the draught was provided by pipes inserted in the base of the kilns, which caught the sea-breeze. In Africa and the Farther East, varieties of bellows were devised to increase the heat of the fire. In pre-Columbian Central America, the metallurgist blew the fire with his own breath through a pipe with a small aperture. But in the course of discovery of the properties of metal, the facts that it was malleable, tenacious, and responsive to heat led to the process of casting. And in casting, the properties of alloys were discovered.

BENIN BRONZE. *In many respects brutal savages the natives of Benin, S. Nigeria, were masters of the art of bronze casting.*
British Museum

Alloys. Of these, bronze and (later) brass are the most important from the economic point of view. Metal alloys possess the peculiar property of melting at a lower temperature, and yet have a harder consistence, than either of the parent metals. It is difficult to cast copper, because it develops a spongy texture. But if tin is added, it solidifies and, as bronze, can provide an edge, if hammered, nearly as good as iron. Copper, with an admixture of zinc (unknown to primitive peoples) produces brass, which also flows freely into a mould. It so happens that tin ores, especially in the Americas, occur together with the copper ores; so that much of the pre-Columbian copper is an accidental bronze, more easily cast and with a better texture than copper.

Methods of Casting. Probably the first method of casting, before the principles of alloys were understood, was the simple pouring of molten metal into open moulds made in sand or earth. But this did not provide for an object in the round and was wasteful of metal. All raw metal was precious; a process of casting was evolved in many parts of the world which solved the problem of economy in use. The discovery arose from the 'lost model' process, in which some small object, destructible by fire, was wrapped in clay, baked and then replaced by molten metal poured in through an orifice left for the purpose. Many of the brass 'gold-weights' of Ashanti, representing a crab's claw, a bird's foot or a peanut, were made by this process.

But the really economical method is that known as *cire-perdue*. Suppose the artisan—to take an instance, again from Ashanti—desires to reproduce the figure of a porcupine. A core composed of clay and charcoal, giving the basic shape, is prepared and fired. This is covered with strips of wax, which are spread smoothly. Details, such as the spines, are added in wax; the whole is then covered in successive coatings of liquid clay. When the coatings are complete, the shape is wrapped in a casing of clay mixed with vegetable fibre, to render it porous. A wax 'stem' leads to the exterior of the mould; over this is placed a cup of fired pottery containing brass filings and strips. The whole is then enclosed in solid clay, left to dry, and placed in the fire. Bellows are applied to the end of the mould which contains the metal. The wax melts, is absorbed by the porous inner coating, and the metal replaces the wax around the core. After cooling, the mould is broken; if the process has been carried out successfully, the metal casting, enclosing a core of inexpensive material, gives a faithful reproduction of the original wax model.

The *cire-perdue* method was introduced into Africa from Europe in the earliest days of colonization; it was by this method that the famous Benin bronzes were manufactured. But the process was known also in ancient America before Columbus, especially in Costa Rica and Colombia.

BOOK LIST

General. 'Anthropology,' Sir E. B. Tylor (Macmillan); 'Anthropology,' R. R. Marett (O.U.P.); 'Corridors of Time,' H. Peake and H. J. Fleure (9 vols. O.U.P.); 'The Golden Bough,' Sir J. G. Frazer (Macmillan); 'Primitive Culture,' Sir E. B. Tylor (Murray); 'Ancient Hunters and Their Modern Counterparts,' W. J. Sollas (Macmillan); 'Man in the Making,' R. R. Marrett (Nelson); 'Mutual Aid," Peter Kropotkin (Penguin); 'Manners and Customs of Mankind,' ed. Sir J. A. Hammerton (3 vols. Amalgamated Press).

Physical. 'Antiquity of Man,' Sir A. Keith (Williams and Norgate); 'Races of Mankind,' H. J. Fleure (Benn); 'The Human History,' Sir G. Elliot Smith (Cape); 'Races of Man and Their Distribution,' A. C. Haddon (C.U.P.); 'We Europeans,' J. S. Huxley, A. C. Haddon and A. M. Carr-Saunders (Cape); 'The Races of Africa,' C. G. Seligman (O.U.P.).

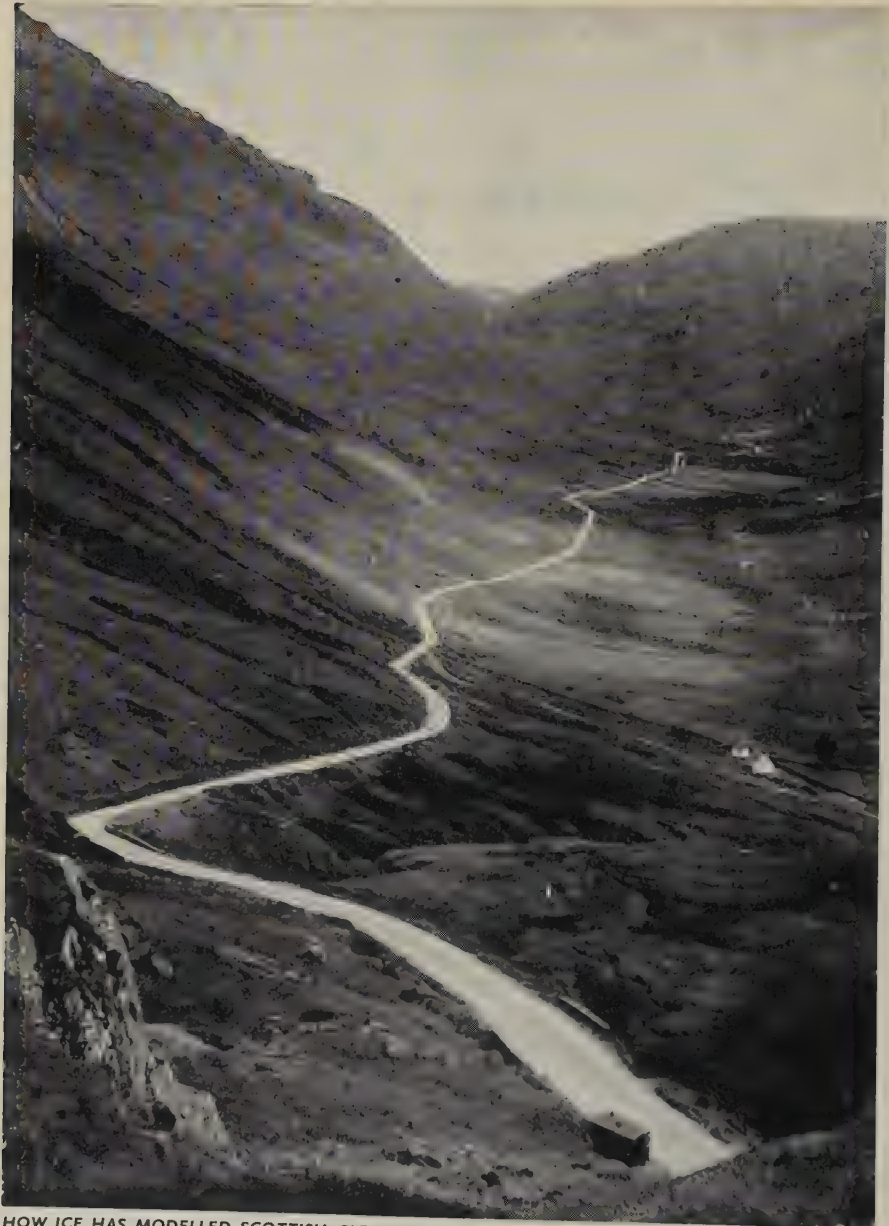
Social. 'Patterns of Culture,' Ruth Benedict (Routledge); 'At Home with the Savage,' J. H. Driberg (Routledge); 'Origin of Magic and Religion,' W. J. Perry (Methuen); Social Organization,' and 'Medicine, Magic and Religion,' W. H. R. Rivers (Kegan Paul); 'Short History of Marriage,' E. Westermarck (Macmillan); 'Man Makes Himself,' V. G. Childe (Watts).

Special Studies—Africa. 'An African Survey,' Lord Hailey (O.U.P.); 'Races of Africa,' C. G. Seligman (Thornton Butterworth); 'Stone Age Africa,' L. S. B. Leakey (O.U.P.); 'Tribal Studies in Northern Nigeria,' C. K. Meek (O.U.P.); 'The African Today and Tomorrow,' D. Westermann (O.U.P.).

Asia. 'Peoples of India,' J. D. Anderson (C.U.P.); 'Pagan Tribes of Borneo,' C. Hose and W. McDougall (Macmillan); 'Peasant Life in China,' Hsiao T'ung Fei (Routledge); 'The Indian Peasant Uprooted,' Margaret Read (Longman); 'Mother India,' Katherine Mayo (Cape); 'The Todas,' W. H. R. Rivers (Macmillan); 'The Veddas,' C. G. and B. Z. Seligman (C.U.P.); 'Malay Magic,' W. W. Skeat (Macmillan).

America. 'The Eskimos,' K. Birket-Smith (Methuen); 'Mexican Archaeology' and 'South American Archaeology,' T. A. Joyce (Macmillan and Warner); 'The American Indian,' C. Wissler (O.U.P.).

Australasia and Oceania. 'Stone Men of Malekula,' J. Layard (Chatto); 'Argonauts of the Western Pacific,' 'Crime and Custom in Savage Society,' and 'Sexual Life of Savages in N. W. Melanesia,' B. Malinowski (Routledge); 'The Arunta' and 'Native Tribes of Central Australia,' B. Spencer and F. J. Gillen (Macmillan); 'Coming of Age in Samoa,' Margaret Mead (Cape); 'Primitive Economics of New Zealand Maori,' R. W. Firth (Routledge).



HOW ICE HAS MODELLED SCOTTISH GLENS. The smoothness and symmetry of the glens of the Highlands, characteristics which contribute so much to their charm, are the result of glacial action in remote times. The flowing slopes of these hillsides in the pass of Glencroe (not the more famous Glencoe), Argyllshire, are thus a tribute to the unconscious art of Nature in the Ice Age.

Photo, W. F. Taylor

GEOLOGY

OFTEN regarded as a dry-as-dust subject dealing with dead rocks and stones, Geology, as presented in this Course, is seen to be a study of deep and living interest. We learn of fantastic and remarkable creatures of early geological times that lived and disappeared many millions of years ago, we read of the long story which the world itself in the rocks and their fossils tells us, and we obtain information of direct practical value concerning the chalks and clays, coal and mineral and other deposits immediately beneath the surface on which we pass our lives. Particular attention is paid throughout to the geology of the British Isles.

Certain aspects of Geology lead into other subjects such as those covered by the Courses on BIOLOGY (*Vol. II*), ZOOLOGY *and* PHYSIOGRAPHY (*Vol. IV*), ARCHAEOLOGY (*Vol. I*) *and* ECONOMIC GEOGRAPHY *in Vol. VI.*

20 LESSONS

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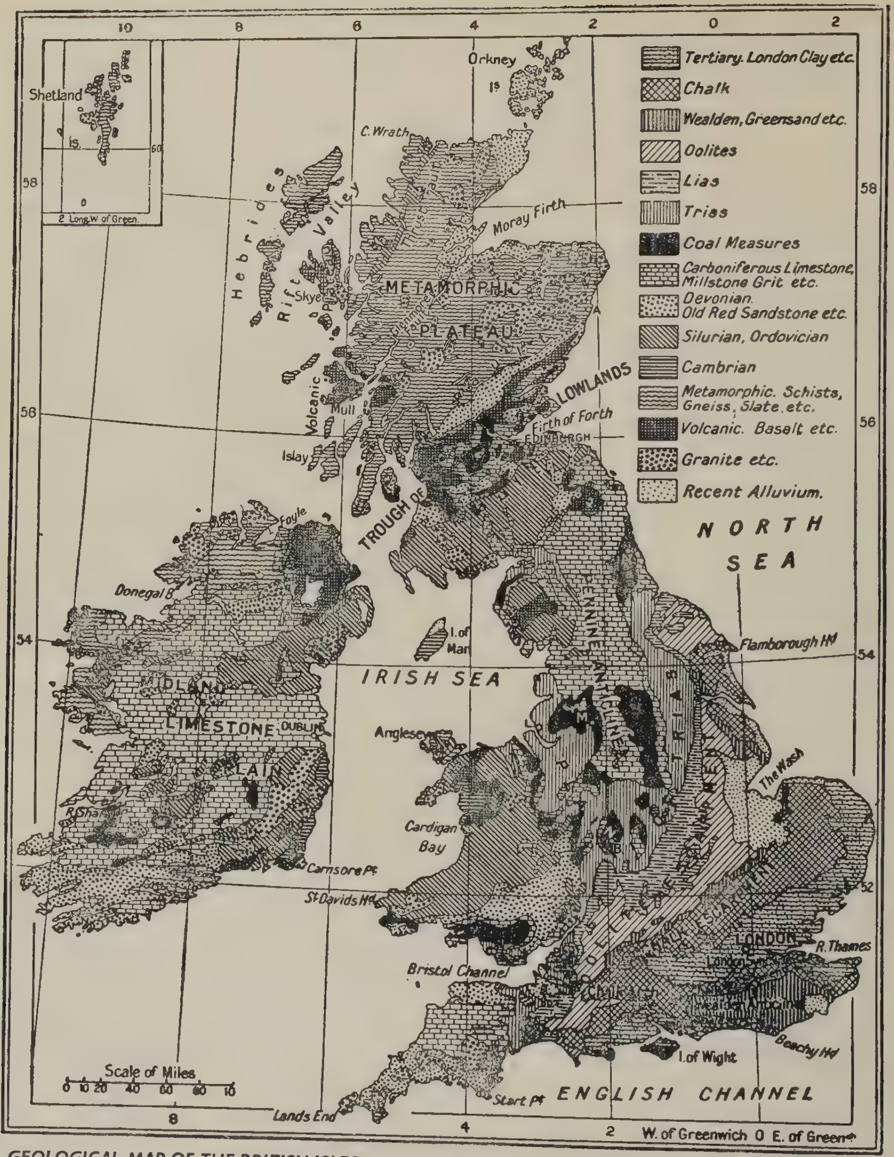


GEOLOGICAL MAP OF THE BRITISH ISLES. *From the point of view of the geologist, Great Britain and Ireland afford a very interesting study, for virtually every type of formation is present. Hence the innumerable scenic differences, from the rocky wildness of the Scottish Highlands to the low chalky ridges of south-east England and the alluvium of the Wash. In this map the surface evidence of the great geological periods is indicated, as well as the principal types of rock formations. In the pages which follow there are other maps showing in greater detail the visible signs over Great Britain of those great changes wrought in the earth's crust by the violent upheavals and climatic revolutions of primitive times.*

From 'Wonders of the Earth's Crust,' by H. E. Taylor, F.G.S. (Pitman)

LESSON ONE

The Rocks Tell Us the Story of the World

Geology is the science that carries us back through countless ages to that remote time when a solid surface began to form on the earth, which hitherto had been a radiant sun in the heavens. It conducts us through a marvellous vista of reality, and enables us to witness the pageant of the prehistoric past. Its ever-changing scenes, in which strange beings in countless myriads come and go, follow one another in orderly sequence through uncountable aeons until we encounter the archaeological and historic record of Man.

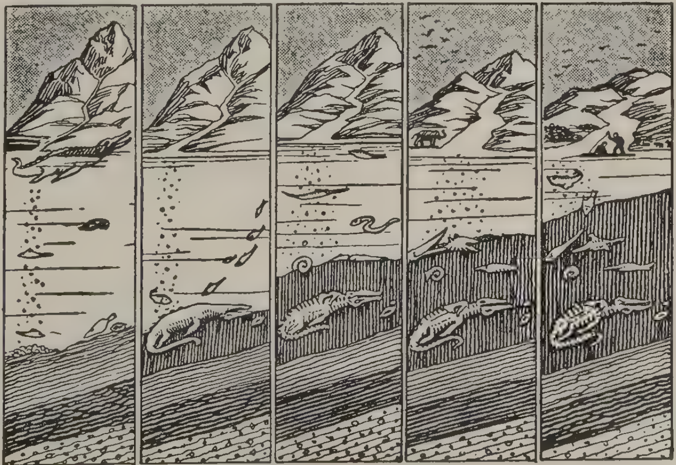
Few records are so fascinating and none so vast and varied as those revealed by the rocks. The creatures that flourished in the various periods of that long-lost past are as real as those which exist now. Moreover we, together with all the world of living things today, are the direct descendants of many of those singular forms of life that are found in such multitudes deep down in the rocks and strata of a hundred million or maybe a thousand million years ago.

The successive layers of material in which the long geological record is found make a colossal volume, the existing pages of which, in the form of strata, would if placed one upon the other, reach to a height of about 14 miles. The study of these layers—of rock, sand, clay, and so on, many hundreds of feet thick—is called *stratigraphy*.

It is only in the sedimentary rocks that the life-forms are preserved to us. As such they are known as fossils, and their study as *palaeontology*. The details of geology and palaeontology are so interwoven that they will be treated contemporaneously in most of the succeeding Lessons. Thus successive pictures, as it were, of those times will be presented, together with a description of the stratified rocks or *beds* in which the fossils of the period may be discovered.

Quite easily the student may acquire a collection of the smaller of these petrified forms of life for himself; and later on we shall mention the areas where particular fossils have been found and where, therefore, further similar finds are likely.

Prehistoric Fossils. Occasionally a large and wonderful specimen is unearthed, as was the case at Harbury, near Leamington, in February 1928, when an immense amphibian, a kind of sea-lizard with a swan-like neck, known as a plesiosaurus, was dug up (p. 66). It was 16 feet long when discovered, lying just where it had died at least 100 million years before. The sea in those days rolled over the greater part of what is now southern England; but since the creature's death some 40 feet of clay, sand, and limestone had been deposited upon its remains. Another gigantic specimen came to light in the following November, when an ichthyosaurus, a thick-necked sea-lizard or saurian, 30 feet long, was discovered in the Harbury quarries at a depth of 42 feet. It was esti-



HOW FOSSILS HAVE BEEN PRESERVED. *The drawings given above represent the gradual denudation of a land-mass and the consequent deposition of a series of layers or strata on the floor of the ocean. As the result of tremendous and enormously prolonged pressure these became converted into rock, effectually sealing up within themselves the skeletons, shells, etc., of the primitive creatures that lived and died when the strata were being laid down.*

PREHISTORIC MONSTER. This wonderful fossil of an amphibian, plesiosaurus, was discovered in 1928 in a quarry at Harbury, Warwickshire. It is 16 ft. long, and is evidence of swamp life in a long-dead world.

mated by Professor W. E. Swinton, of the department of Geology at the South Kensington Museum, that it had lived between 100,000,000 and 200,000,000 years ago.

In October, 1925, while excavating for the foundations of the Daily Mail building, many beautiful fossils of the great pearly nautilus were dug up. Weighing several pounds each, they retained the iridescent sheen on their shells produced by the sunlight of several million years ago, when London and the Thames estuary had no existence and in their place was a subtropical swamp, set near the edge of a great delta not unlike that of the Ganges of today.

These are but typical recent examples, though the finding of the fossilized remains of very large creatures is rarer than is the case with smaller subjects, This is chiefly owing to the difficulty of access to areas from which large quantities of superimposed material are being removed, such as a quarry or the foundations of a big building. On the other hand, numbers of small fossils may be acquired in a day's ramble in suitable localities. Sometimes they may be found just below the surface mould of our gardens. When we remember that these fossiliferous sedimentary rocks and strata may descend for miles below the earth's surface, we shall understand what a wealth of fossil treasures yet remains hidden, to provide a never-ending source of evidence for those far-off times.

Igneous Rocks. Below the sedimentary strata are the fire-formed and crystalline rocks. These are known as *igneous.* Now though all igneous rocks are not necessarily the most ancient, yet when they exist beneath undisturbed sedimentary rocks they are unquestionably of greater age, and constitute the foundations upon which rest the stratified fossil-containing rocks. Their thickness is enormous—30 to 40 miles, sometimes more.

Here we enter another section of geological study which takes us back from about 1,000,000,000 to 8,000,000,000 years or more. We cannot, of course, go down miles into the bowels of the earth to study these rocks, but, nevertheless, we have access to most, if not all of them, owing to the fact that in the course of ages they have been upheaved and laid bare all over the earth. The innumerable upheavals and convulsions have continually re-formed and transformed the earth's growing 'crust'; portions have been raised, tilted, turned up on end, and so shifted in relation to adjoining rocks and strata that masses of rock which might otherwise be many miles below the surface are now actually at the surface.

Reading the Records. It so happens that the geological foundations and also the superstructure of sedimentary rocks in Britain have been so tilted through the ages and then worn down through denudation to the convenient level of our countryside, that we may read their marvellous geological record as if from the pages of a book, by the simple expedient of travelling west or north from, say, London or the estuary of the Thames. Each page in the book represents a period in geological time and carries us farther back towards the beginnings of our world. Thus a field for holiday research is opened up, and a new interest is added to our travels.

The Practical Value of Geology. From the practical side, too, geology is really a very valuable science. Before an expensive tunnel can be bored, a mine-shaft sunk or a deep well drilled, the geology of the locality has to be exhaustively studied, or very large sums of money may be lost in fruitless endeavour. Again, we are all aware of the great value of some of the mineral contents of the rocks; geology indicates where they are most likely to be found.

Such problems as the vanishing mineral products, the depletion of our coal reserves, and the probable scarcity of petrol in the near future are all geological subjects and will be considered in later Lessons.

LESSON TWO

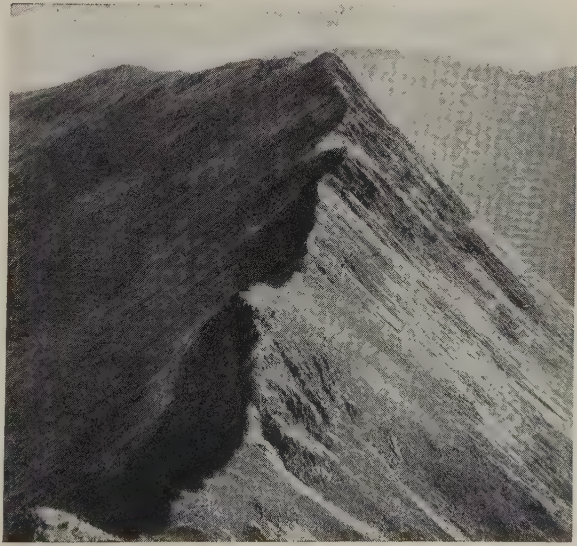
Geological Character of the British Isles

It is well known that the ground beneath our feet varies very much according to the locality in which we happen to be. In one area it is sandy, in another it is clay, while elsewhere either dark rock or maybe white chalk abounds. A closer observation will reveal a great and interesting variety.

Layers of Rock. These may be seen quite easily in a train journey where we are carried through a succession of cuttings. In one place layers of sandy-looking rock, of reddish, yellowish or maybe greenish hue, are met with—the layers, or *strata*, lying one upon the other, usually in regular lines at various angles to the surface and rarely level with it. This angle is called the dip of the strata and is measured relatively to the horizon. Farther on we may pass into an area where, from between grassy slopes and tree-capped heights, may occasionally be seen masses of brown, bluish or greenish clay. Freshly dug foundations in much of the London district may be seen to be composed of brownish clay, while clay lower down is found to be bluish.

In most train journeys from London, masses of white chalk will be met with in cuttings and by hillsides towering high above us. Elsewhere grey limestone, craggy and massive as in Derbyshire and Yorkshire, will form well remembered features, while hard angular chunks of red sandstone, together with successive tracts of twisted slaty-looking rocks of various dark hues, will be found to predominate in most hilly and mountainous districts. In distant localities and in districts rarely penetrated by railway cuttings, great grey masses of granite, such as may be seen on Dartmoor, in West Cornwall and over large areas of the Scottish Highlands, make the scenery appear as if strewn with huge ruins of a gargantuan age. Finally, there are those more remote mountainous regions where black basaltic and volcanic rocks are raised in pinnacles and queer outlines against the skyline, as in the Lake District of Cumberland, the islands of Mull and Skye and elsewhere in Scotland. These are the visible remains of the colossal volcanoes that once extended throughout the length of Britain.

Cliff Formations. Again, the coastline often offers the student an attractive opportunity to note the great variety of cliff forms and the various materials entering into their composition. The white chalk of the south-east coast of Kent, of Sussex, the Isle of Wight and the easterly portion of Dorset, is a feature which gave to Britain its ancient name of Albion. Farther west are the curiously bent and twisted layers of sands, clays and limestones of the Dorset coast, followed by the familiar Portland Stone. In Devonshire the red cliffs from Dawlish to Teignmouth, the highly contorted cliffs of Torquay, the coral limestones producing such beautiful marble, and farther north the bright red sandstones, much in evidence in the Lynton area, are striking features.



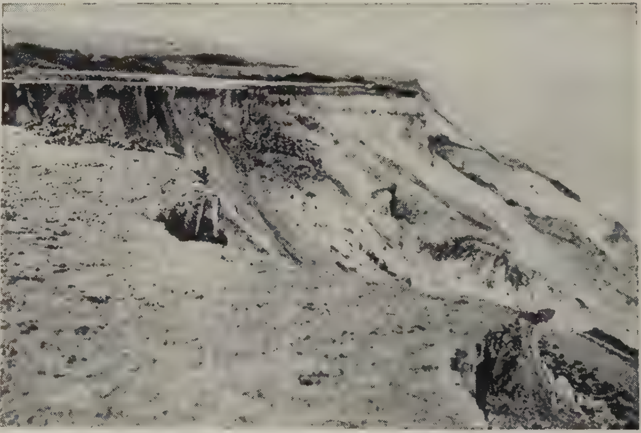
HELVELLYN, on the border of Cumberland and Westmorland, is a magnificent memorial of the enormous volcanoes that existed in the Lake District during the Ordovician Period. They testify to a gigantic upheaval at least 200,000,000 years ago.

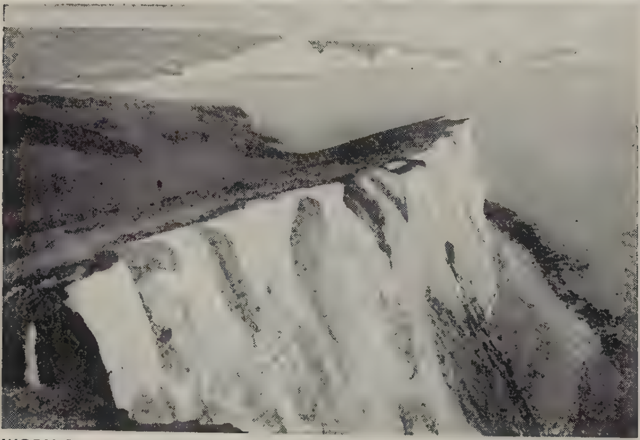
Photo, G. P. Abraham

Then, in the extreme south of the county of Devon, may be seen cliffs composed of the earliest stratified rocks, which were formed probably before life appeared on earth. In the Lizard district of Cornwall similar rocks are found together with magnificent cliffs of multi-coloured marble, the serpentine that is fashioned into works of art. Huge cliffs of grey granite, a fire-formed crystalline rock, constitute the Land's End area, while the many-tinted and rosy sandstone cliffs of the North Cornish coast are a rendezvous of artists. North Devonshire is much the same, with its sharp-angled red sandstone cliffs weathered into many hues rising for a thousand feet above the sea.

In Wales the grandeur and wealth of colouring in the cliff formation is just as great, particularly in South Wales, where totally different types of rock succeed one another in the course of a walk. Some readers may call to mind the bluish and slaty rocks of North Wales; in these some fossils of the earliest forms of life are found, strange creatures that lived at least 500 million years ago.

The student will find the cliffs of Suffolk and Norfolk very different. They are noteworthy for their yellow, orange and reddish hues, their friable texture and tendency to fall away. They are among the newest of Britain's cliff formations, as are those of south-east Yorkshire, and are composed of glacial drift and boulder clay, the materials left behind by glaciers, from 100,000 to 500,000 years ago and possibly more. Farther north, in Yorkshire, great chalk cliffs reappear at Flamborough, the strata having passed beneath the whole of south-east England from the cliffs of the south coast. At Scarborough the massive rocks are of limestone built up largely by coral many millions of years ago.





WORN BY TIME AND TIDE. Above, Seaford Head and the Seven Sisters, on the Sussex coast; they were once beneath the sea. Top right, the cliffs at Cromer, crumbling away as the result of the constant pressure of the tidal current flowing towards the Wash.

Lower photo, Frith

Still older and harder rocks form the various types of cliff the nearer we approach Scotland, until cliffs of hard rock almost identical with those met with in Devonshire and Wales appear north of the Tweed. A succession of very ancient rocks, chiefly hard red sandstone, limestone and volcanic material, compose the cliffs of the east of Scotland until the great masses of grey and red granite are met with on the coasts of Aberdeen and Banff. Around the Moray Firth and northwards to Caithness and the Orkneys, the cliffs and materials composing them are similar to those of Devon and Cornwall, while those of the Western Highlands and islands resemble, alike in age, materials and massive conformation, those fringing the mountainous districts of North Wales, except that in the north they are on a vaster and grander scale.

From this preliminary survey of the geological character of the cliffs of Great Britain, an idea of the great variety of material entering into the foundations of the land may be obtained. The entire series has been reliably calculated to represent at least 800,000,000 years of the earth's geological record, and probably 1,200,000,000 years. The acceptance of this higher estimate of the probable duration of the geological record as represented by *existing* rocks is based on the evidence of the radio-active rocks containing barium and thorium in particular, which go through a transformation, as does radium, but at a much slower rate and after an enormous lapse of time (*see* Chemistry, Vol. III, Lesson 26, pp. 236–238).

Such evidence has been obtained from a plutonic, that is fire-formed, rock known as pegmatite, which occurs as veins in granite. Analysis of specimens of pegmatite, which are known to be among the oldest of existing rocks, indicate that the great masses of granite containing it must have become solid at least 1,200,000,000 years ago.

As there must have been rocks existing before this to form the pegmatite in the granite, the probable age of the earliest solid crust for the earth is extended to a still more remote period, even though we have no material of this original crust remaining or accessible to us now. This would be owing to the successive cooling and remelting of the first solidified rocks. Sir James Jeans summarizes the matter thus:

> We cannot say how long these earlier processes lasted, but they must have lasted through many millions of years, so that it hardly seems possible that the earth should be less than 1,500,000,000 years old. The earth cannot be enormously older than this, since, if it were, its radio-active substances would all have disintegrated away by now, and the phenomenon of radioactivity would have been entirely unknown to us.

This is, of course, as regards the solid crust, for the earth as a molten body would be a very great deal older than this.

The Student's Equipment. A knowledge of what may be seen and found gives an additional zest to rambles when the student knows the most likely places in which to investigate the exposed strata. He needs very few implements for their study. The chief is a geologist's hammer, preferably one with a chisel edge. This will facilitate the extraction of fossils. A pocket knife with a large steel blade suitable for scraping rocks and fossils, and equal to hard wear; a magnifying lens, a pocket compass, and a Geological Survey map of the district are also necessary. The map on a one-inch scale usually covers an area about 20 miles by 12, and will be found indispensable. An Ordnance Survey map of the British Islands is also necessary. Coloured maps should be obtained.

As the student progresses other instruments will be required. Among these are a magnet and a clinometer for strata study: the latter for measuring slopes and angles at which they lie relative to the horizon; the former for detecting iron-bearing rocks. Later on, chemicals may be required for analysing rock substances and, most desirable of all, a petrological microscope; this with polarizing apparatus will provide a never-ending source of interest and entertainment. Cases will eventually be required for storing the specimens as they accumulate.

LESSON THREE

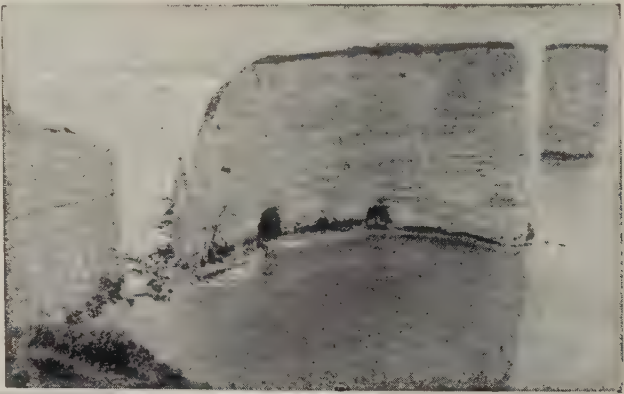
How Geologists Classify the Rocks

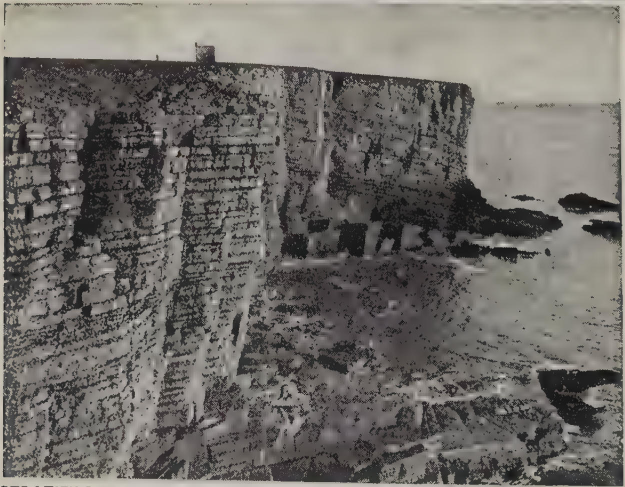
In our second Lesson the student learnt that almost every type of rock and also strata of every period of the earth's geological history are to be found somewhere on the surface of Britain. These comprise hard stone, soft sand, clay and friable materials, all in a variety of colours and with many features peculiar to each. Thus although two samples of rock may be similar in colour, their texture will perhaps be different; or one is flaky while another, very similar, is brittle, and so forth. These peculiarities are usually the means whereby the rocks are identified, since they owe their origin to the circumstances producing the particular rock. All solid materials, whether sand, clay or hard stone, are rocks when geologically considered, and everywhere these are classified according to their origin.

Classes of Rocks. The classification by texture is into crystalline and non-crystalline rocks. A close scrutiny of a collection of various rocks will show that some of them consist of crystals, more or less small, and in certain varieties all bound together as if with cement. Granite is an admirable example. Other rocks consist of non-crystalline particles held together as with cement, or by cohesion. Sandstone, flint, clay and chalk are common examples of such rocks. Although a microscope is sometimes necessary to distinguish whether a rock is crystalline or not, this distinction is necessary because it gives the student the first clue to the origin of the rock.

The second principle of rock classification, which gives a clue to its origin, is whether it is stratified or unstratified. This is often only to be learned by observing the rocks on a cliff face, in a cutting, quarry, or some foundation where plenty of material is exposed below the normal surface of the ground. There, a distinct difference will as a rule be seen. Some rocks, being always arranged in layers, though not always parallel to the ground level, are known as strata, that is, stratified rocks. Other rocks, such, for instance, as granite, marble, and basalt, are not thus arranged in parallel layers but as a mass. This mass, which may be as large as a mountain, may have veins, cracks and fissures in it, but they will be at all angles; the veins in marble being an example.

A third principle of classification which greatly helps in identifying and placing rocks in their proper category is the presence or absence of fossils. Some rocks, like chalk and coal, are almost entirely composed of the fossilized remains of life, though much of it is only microscopic. Other rocks contain their own particular types of fossils, many in great variety, and so distinctive that strata in distant parts of the earth can thereby be placed in their relative position as regards age. (For the evidence of evolution in fossils *see* Biology, Vol. II.)





***STRATIFIED ROCKS.** Above, cliffs of gently-inclined thin-bedded carboniferous limestone at Linney Head, Pembroke. Top right, the chalk cliffs at Swanage. The materials composing stratified rocks are various, but all are sedimentary, the layers having been deposited usually by water, more rarely by wind.*

Photos, Geological Survey and Museum; and H. Felton

If we study all rocks by means of this classification, the three methods will together show that a rock which is crystalline is also unstratified and contains no fossils. Stratified rock is almost always non-crystalline and is usually fossiliferous. Finally, if we have a small portion of rock containing a fossil, this will prove that the rock is sedimentary, stratified and non-crystalline, even though crystals are present around the fossil. This occasionally happens in very ancient rocks.

Crystalline Rocks. We have thus two sharply defined classes into which nearly all rocks can be divided. These are: crystalline, which are unstratified and non-fossiliferous; and non-crystalline, which are stratified and fossiliferous. Those in the first class are invariably igneous, that is, formed through the agency of fire. The crystals have been formed when the material solidified after being molten, and this accounts for the absence of fossils in igneous rocks. Further subdivisions, named eruptive, plutonic, and volcanic, are used to describe certain igneous rocks. These rocks must, therefore, either have been poured forth in a liquid form as lava and basalt by volcanic action, or must have welled up as a vast molten mass under pressure, which when cooled formed granite.

Sedimentary Rocks. The second class consists of sedimentary rocks which usually appear stratified, the materials being deposited, most often by water, in easily seen layers or beds. A bed represents one vast layer, often of great thickness, such as the bed of clay under the London area; or it may represent several layers of a similar rock which together constitute a bed. In various ways water deposits the materials of the stratified rocks, whether as sand, to form sandstone, as mud, to form clay, or as organic remains mixed with various proportions of sand, or mud, or both, to form other types of strata, such as chalk. Occasionally wind produces the strata. Pressure and chemical action through the ages, in some cases through hundreds of millions of years, have welded many of these sands and muds into rocks of great hardness, such as the limestones and sandstones which are used for building and paving.

Metamorphic Rocks. There is yet a third class of rocks, known as metamorphic, which are sedimentary strata that have been affected by fire, the earth's internal heat, combined with great pressure. Thus clay may become metamorphosed into slate by this prolonged baking and pressure. Limestone may thus be transformed into marble, and the rocks known as serpentine and schists come to be formed—these being really metamorphosed sedimentary rocks, i.e. rocks formed first by the agency of water and then baked by fire.

A small fourth class of crystalline rocks which are not igneous but are chemically produced by the agency of water, consists of those produced by calcareous deposits, such as stalactite and stalagmite in caves, and also by the precipitation of silica and other chemicals. These exceptions do not, however, affect the grouping of rocks into the above main classes.

LESSON FOUR

The Volcanic Age in Britain

THROUGHOUT the western half of Britain, from the extreme north in Sutherland to the extreme south in Cornwall, are found the fire-formed relics of its past. These are the igneous rocks. Some may be no more than 10,000,000 years old since they were poured forth as vast streams of lava; others may be 2,000,000,000 years old. They may easily be studied if the student knows where to look, for they come to the surface at many readily-accessible places.

In the last Lesson the student has been made acquainted with the classification of the rocks into igneous and sedimentary. But there was once a time when there were no sedimentary strata, and igneous rocks alone constituted the earth's comparatively thin surface crust. These were not always similar to the igneous rocks as found today although some may have been so. The differences in the fire-formed rocks are considerable and depend largely upon the conditions under which they were formed. All the igneous rocks were once liquid, like the lava which pours from a volcano, but not all igneous rocks were produced thus—only those that are known as volcanic. Others, the plutonic, were produced deep down in the earth and solidified slowly under great pressure, and are often different in character and texture.

The volcanic rocks, which cooled on or near the surface, solidified far more quickly and are, therefore, marked by a much finer crystalline structure. Sometimes, as in obsidian, or so-called volcanic glass, they

PUMICE STONE. This familiar substance comes from lava 'froth.'

show no crystalline structure. They are often full of holes produced by the escaping gases with which the lava was charged when it was emitted from the volcano. A kind of fiery surface froth which thus formed on the white-hot lava produces the familiar pumice stone. These volcanic products are known as superficial, because they were poured out in vast sheets, sometimes of great thickness, upon the surface. Other volcanic rocks are known as intrusive, because they are thrust up from a molten interior through cracks and fissures in the superimposed rocks and thus form dykes and bosses.

The plutonic rocks are very different from the volcanic ones. They were solidified deep down under the earth and cooled so slowly that they frequently developed a coarse crystalline structure. The immense pressure of the superincumbent strata, often 10 or 12 miles thick, compacted these rocks as they cooled and gave them a very close texture. Volcanic rocks show small crystals, or perhaps none at all, and are often loose in texture or full of holes. Plutonic rocks are close and as a rule show large crystals.

Process of Crystallization. The crystallization of rocks may be understood if the student bears in mind that all the igneous rocks were once a liquid similar to molten glass, at a white heat maybe, but, like the glass, consisting of a mixture of silicates. They were not necessarily transparent, because they contained a great many impurities and colouring matter from which glass is usually free. Sometimes this molten glassy rock cooled, as in the case of obsidian, into a substance indistinguishable from coarse glass.

Other conditions of cooling and pressure caused its component elements to arrange themselves into crystals corresponding to their chemical composition; the slower the cooling the more complete the process of crystallization. Sometimes the process was cut short before completion, and part of the molten matter had crystallized, while the remaining magma, as it is called, solidified before it had time to crystallize. Consequently we find igneous rocks which may be wholly crystalline—granites, for example; others which are partly so, having the crystals set in a formless matrix or cement, such as porphyry. Others—obsidian, for example—may not form crystals at all. To know the characteristics of the igneous rocks by sight it is essential that museum specimens be studied.

Volcanic Areas. Igneous rocks come to the surface in many parts of our country, particularly in the west and north. The nearest locality to London is in the Charnwood Forest area of Leicestershire, where, stretching in a line across the county, north-west of Leicester, may be seen the remains of one of the oldest mountain masses in England. Volcanic in structure, porphyritic rocks occur at Peldar Tor and Bardon hill, apparently part of an ancient volcano. Masses of granite compose Mount Sorrel, while syenite, a rock similar to granite and of volcanic origin, exists in large masses at Grooby, Markfield, Croft and Enderby. The whole region was volcanic hundreds of millions of years ago. Volcanic tuff, a rock formed from volcanic dust, and breccia, a rock composed of fragments of lava mixed with volcanic dust and débris, occur at Barnt Green, near Birmingham, and at Caldecote, near Nuneaton.

The Malvern hills possess a core of the oldest type of rock, highly crystalline gneiss. This is a foliated granite, exactly the same in composition, but which has been through long ages subjected to great heat and pressure. Gneiss may, therefore, be regarded as granite metamorphosed by heat, and as such it is included among metamorphic rocks. Associated with tracts of volcanic basalts, andesites (named after the Andes), and felspathic tuffs, a rock formed from erupted material, the Malvern hills are thus shown to have been once a volcanic region.

A similar volcanic area is that of the Wrekin, in Shropshire, known as the Uriconian. The Wrekin, one of the oldest mountains in England, is made up of successive layers of lava. Granitoid rocks occur at Ercall hill and gneiss at Primrose hill. The area to the west and south of Wellington is, therefore, largely volcanic. Farther south-west, Pontesford hill, on the west of the Longmynd, is chiefly composed of lavas, as also is a large area to the east of Church Stretton, including Caer Caradoc and Cardington hill. North of Bishop's Castle are other volcanic areas, doubtless outcrops of the volcanic system of North Wales.

Dartmoor and Cornwall. The Dartmoor area of Devon consists of an elevated mass of granite extending for about 20 miles east to west and 25 miles north to south, i.e.

from near Okehampton to South Brent. Brent Tor is composed of volcanic rock erupted over 100,000,000 years ago. South-west of Exeter are other very ancient volcanic rocks that extend in patches southward to the Dart. Thence a broad belt stretches westward to near Plymouth, the volcanic rocks protruding through the very ancient sedimentary strata. North of Tavistock, and at Marytavy and Milton Abbot in the Brent Tor district, are rocks that are the products of volcanic fires. These extend into Cornwall at Callington and encircle the elevated Bodmin Moor both north and west.

A mass of granite 10 miles by 12 composes this Bodmin Moor, which rises to a height of 1,364 feet in Brown Willy. A lesser mass extends from near Lostwithiel to St. Austell and westward to Tregonna hill, while yet another, from Penryn almost to Helston, protrudes to reveal the fire-formed foundations of Britain. The whole of the area from St. Ives to Land's End and encircling Penzance is an extrusive mass of granite, St. Michael's Mount being a noteworthy pinnacle of this rock, while the Scilly Isles are but projecting areas of an enormous mass of granite that sinks down beneath the Atlantic, how far we do not know. Lundy Island is another example.

Lake District. Very different are the fire-formed rocks of Cumberland and Westmorland. There volcanic porphyries, partly crystalline, compose the crags of Borrowdale, Scafell (3,210 feet), Honister Crag, the Wastwater crags and Helvellyn (3,118 feet). These reveal a great volcanic upheaval in what are known as pre-Devonian times, at least 200,000,000 years ago, and probably much more. Over an area about 30 miles by 15, from Ambleside to near Keswick, and from the Shap Fells almost to the sea, vast streams of lava and masses of volcanic material several thousand feet thick remain as evidence. In the west around Ennerdale Water, in Wastdale and the Eskdale areas granite protrudes, as it does at the Shap Fells.

While some of the oldest igneous rocks both volcanic and plutonic are found at the surface in relatively small and isolated patches in the west and north of England, it is water-formed sedimentary rocks that cover by far the greater part of the country, often to very great depth. In Wales the conditions are very similar, except that most of the rocks, although sedimentary, are generally very much older than those found in England, nearly all the surface beds that are not igneous being of the Primary era.

Plutonic Rocks. The plutonic rocks have usually been thrust up from the lower parts of the earth's crust by hydrostatic pressure and have been intruded into other rocks of more ancient formation. There they have solidified under considerable pressure. The molten masses thus squeezed upward naturally took the line of least resistance, and the various shapes into which they expanded depended on the local conditions. We now find them mainly in one of four distinct formations: as bosses, or shapeless lumps of rock, often many miles in extent; as sills, or flat and roughly horizontal sheets of rock; as dykes, or veins of rock, which have filled up the cracks in earlier formation; and as volcanic necks, which occupy the pipes and craters of ancient volcanoes.

Granite bosses are to be found in south-west Scotland; and the Salisbury Crags, beside Arthur's Seat, Edinburgh, and Stirling rock, both consist of a thick sill. In the north of England the Great Whin sill extends for 80 miles from about six miles south of Durham westward into Cumberland. Veins, or dykes, of intrusive rock are often found on seashores, as at Elie in Fifeshire, where the wearing down of the softer adjacent rock has left them standing up like walls. The mineral veins in which many ores are found are generally intrusive dykes which have been run into cracks in the older rock. Finally, the lava plugs of ancient volcanoes, hardened with age, form the conical hills often met with in North Wales and south-east Scotland.

Volcanic Stratification. Volcanic rocks are distinguished from plutonic by the fact that they are usually found with a kind of false stratification in which the volcanic lavas and tuffs alternate with true sedimentary strata. It is easily seen how this comes about. Volcanic action, it should be remembered, is seldom continuous; the eruptions are separated by long periods of quiescence. At each period of activity the volcano sends sheets of lava welling out in all directions from the vent. When the flow ceases, these sheets harden into rock. The ordinary atmospheric agents then set to work to cover this sheet of igneous rock with the débris of which all sedimentary beds are composed. After this layer has attained a certain thickness, depending upon the length of time that has elapsed since the volcanic activity, a new eruption occurs and more lava covers the sedimentary layer, baking, hardening and, perhaps, chemically altering it.

Thus in the lapse of ages we get a characteristic piece of volcanic stratification, in

RELIC OF VOLCANIC ACTIVITY. Dungoyne hill, near Stirling, whose stumpy cone, worn down by weather, is the lava plug that once filled the vent of a volcano in early Carboniferous times.

Photo, G. P. Abraham

which sheets of lava alternate with layers of sedimentary rock. These stratified layers of alternating fire-formed and water-formed rock often, in the course of many millions of years, become subject to curvature, tilting, crumpling, and dislocation in a manner resembling true sedimentary strata.

Volcanic Rocks of Wales. Examples of these various forms of volcanic and plutonic activity are to be seen in many parts of Wales and over most of Scotland. In Wales the Snowdon and Cader Idris districts are the most famous examples, volcanic ash entering largely into the composition of both mountains and the surrounding area (*see* p. 86). In Cader Idris, it reaches over 2,000 feet in thickness. These massive peaks, together with Aran Mawddwy, constitute the chief remnants of the great volcanic outbursts in the Ordovician era, which was considerably more than 200,000,000 years ago. Down to comparatively recent times (geologically speaking, of course) they were probably much more imposing than at present, for there are evidences that they experienced much wearing down during the great glacial periods, when thousands of feet of slowly-moving ice covered most of Britain. The Arenig mountains, which extend northwards in Merionethshire and link up Cader Iris with Snowdonia, are evidence of further volcanic activity that occurred about the same period. At that time Britain was little more than an archipelago of relatively small volcanic islands.

Throughout Caernarvonshire, and more particularly in the Llyn promontory, bosses of intrusive plutonic rocks, chiefly granite-porphyry, protrude in mountainous masses, of which the Rivals (Yr Eifl) may be mentioned.

Penmaenmawr mountain is another famous mass of intrusive plutonic rock, known as diorite. In South Wales the igneous rocks which reach the surface are nearly all found in Pembrokeshire—St. David's and the area to the north of it being entirely volcanic and composed of some of the oldest rocks in Britain. Skomer Island and to a very great extent Ramsey Island also are of Archaean volcanic material. To the east of Llandrindod are masses of most ancient volcanic rock, the vulcanicity lingering even to the present time in the sulphurous waters of the famous wells.

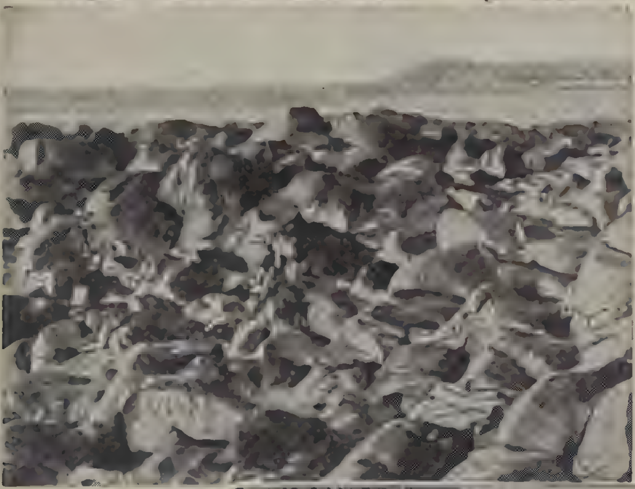
Ancient Volcanoes of Scotland. The finest examples of the ancient volcanoes of Britain are seen in Scotland. The entire island of Mull is the present-day base of a gigantic volcano that once rivalled Etna in size. Out of it poured the immense flows of lava that spread far and wide—even to what is now the island of Staffa, where picturesque tiers of columnar basalt bear witness to the extent of the lava flow. Beneath the sea and extending across to Ireland are extensive sheets of such volcanic outpourings. At the Giant's Causeway, along the northern coast of Antrim, is a wonderful columnar basalt formation; while elsewhere along the coast, particularly in the neighbourhood of Garron Point, the products of the volcanic fires of the Tertiary era may be seen. Nearly the whole county of Antrim is covered with a colossal lava sheet, in many areas over a thousand feet thick, but over most of the country it is hidden by great beds of peat and the drift of ages.

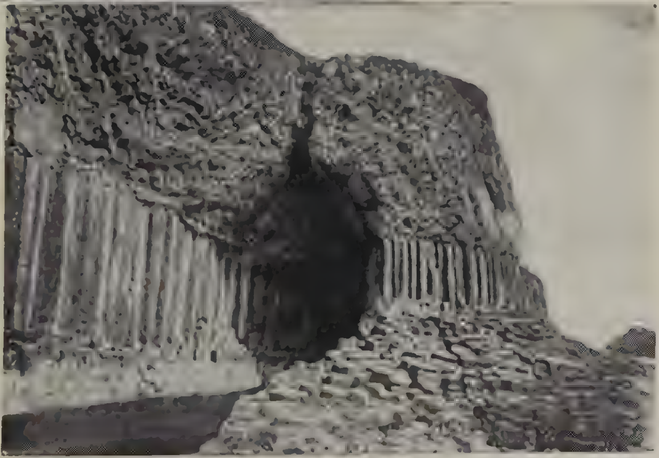
These lava layers constitute an example of volcanic beds overlying older sedimentary beds; they are probably not more than about 10,000,000 years old, and, with the volcanic region of Mull and Skye, they represent a very much more recent era of volcanic activity than the igneous regions of either Wales or Cumberland, which are among the most ancient in the world.

The volcanic area of Northern Ireland is a southerly extension of the great and final outburst on these islands, which extended northward through Mull and the adjoining islands and mainland of Morven to Skye. Here the remains of this volcanic upheaval are seen in their wildest grandeur.

Throughout central and eastern Scotland are the visible remains of a far more ancient volcanic era, that of Ordovician times.

Some are found dating from the Carboniferous period, when so many of the coal-fields of that region were tropical forests. Then volcanic fires spread from the Cheviots in the south to North Berwick Law and thence to Stirling and the rock of Dumbarton; while to the south, through Renfrewshire and Ayrshire, there are stretches of volcanic material. Thus we may picture this region as one of the tropical forests flourishing for long ages and then overwhelmed, in part at least, by repeated out-pourings of volcanic ash and lava.





ANCIENT VOLCANIC ROCKS OF SCOTLAND. In the Ordovician Period Scotland was the seat of violent volcanic activity. Where lava-flows met the sea—as shown in the upper photograph taken near Ballantrae in Ayrshire—the sudden chilling by the water gave them the rounded surfaces of 'pillow lava.' Below, Fingal's Cave on Staffa, where the lava flow hardened into tiers of columnar basalt.

Photos, Geological Survey and Museum and Valentine

Volcanic Activity. The story of successive periods of volcanic activity and quiescence in these islands is very much the same over most other areas of the earth, but whereas it has ceased in Great Britain for some millions of years, other countries, such as Italy, Japan, Java, Mexico, the Andes region of South America and various oceanic islands like Hawaii, are still frequently subjected to the perils of volcanic outbursts on a greater or lesser scale.

It is, however, quite possible that a recrudescence of volcanic activity may occur in the British Isles at some subsequent age, because Britain lies along a belt of present and past disturbance. This extends from the present active volcanoes of Etna, Stromboli and Vesuvius in Italy, through the extinct volcanic area of the Auvergne in France to the Eifel district in Rhenish Prussia, westward from Coblentz, thence through the present extinct volcanic area of Britain to St. Kilda and then to the present active volcanic region of Iceland and Jan Mayen Island whose volcanic mass rises to 6,640 feet above the sea. Hekla in Iceland consists of a row of craters that reach to a height of about 4,500 feet, while numerous geysers also testify to the proximity of subterranean fires. Now Hekla is but 600 miles from Britain and when we bear in mind that there is evidence of great heat at no very great distance below the surface in Britain, as the warm waters of Bath and elsewhere, together with the heat of the mines, reveal, we realize that the possibility of volcanic revival is not altogether remote.

LESSON FIVE

Classification of Sedimentary Rocks

We have learnt something of the oldest rocks of the earth—the igneous. Now we turn to the all-important *sedimentary rocks*. These are composed of material which was originally igneous, but which in the course of ages has been worked upon and partially disintegrated, principally by water, but also by the sun and the atmosphere, frost and wind, and chemical and organic agencies. In the immense period during which these have been in operation, a succession of vast beds of rock has been deposited, each bed being composed of disintegrated portions of the earlier beds, so that in course of time many varied types appeared. These beds, or strata, contain the geological record of the earth's past during this long period.

The most comprehensive classification of the sedimentary rocks, and at the same time the simplest, is that based upon their chemical composition. The great majority are composed mainly of one of four minerals: sand, clay, lime, or carbon. According to the prevalence of one or other of these substances, the sedimentary rocks may be divided into four great families: *arenaceous* (Lat. *arena*, sand) or sandy; *argillaceous* (Lat. *argilla*, clay) or clayey; *calcareous* (Lat. *calcarius*, from *calx*, lime) or limy; and *carbonaceous* (Lat. *carbo*, coal) or coaly, rocks. A fifth class includes the few sedimentary rocks which do not enter into any of these families.

Sand. The *arenaceous* or sandy rocks are composed mainly of sand—which is simply an aggregate of tiny fragments of quartz or pure silica, more or less rounded by friction and not bound together. This sand we are familiar with on the sea-shore, by lakes and rivers, and as the soil of vast deserts. It is the débris of quartz rocks, granite, gneiss, etc., ground to tiny fragments by the wear and tear of ages. Sometimes the disintegratory process has not been carried to the stage when sand is produced, so that we have *gravel* or *shingle* instead. Sand is generally supposed to consist of particles ranging from the size of a small pea down to impalpable powder, whereas gravel consists of particles ranging from a pea to, say, a walnut in size, and shingle of pieces still larger, up to blocks a foot or more in diameter. Further, a distinction has to be drawn between rounded sand or *pebbles*, such as are found on a sea-beach, where the waves have been grinding them against one another until all the corners are worn off, and angular fragments (often of much more recent origin), such as have fallen from cliffs or been left behind by receding glaciers, in what is known as *glacial drift*.

The various forms of quartz detritus known as sand, gravel, shingle, and pebbles form the raw material to a great extent of the principal sandy rocks. They are united so as to form solid rock in two ways. In the first, the pressure of the super-incumbent strata has sufficed to consolidate fine particles of sand into a coherent mass; in the second, the separate particles are held together by a hard cement or matrix, consisting of either hardened sand or clay, or a chemical cement precipitated from solution in water. Sandy rocks owe their variety to the joining of different kinds of particles by different kinds of cement.

Sandstone consists of consolidated sand, held together by its own coherence or by iron oxide (hence the colour of most of the red sandstones), clay, carbonate of lime, silica, etc. Its colour varies according to the chemical composition of the cementing material; thus we have ferruginous, argillaceous, carbonaceous and siliceous sandstones, of a colour respectively approximating to that of iron, clay, coal and silica.

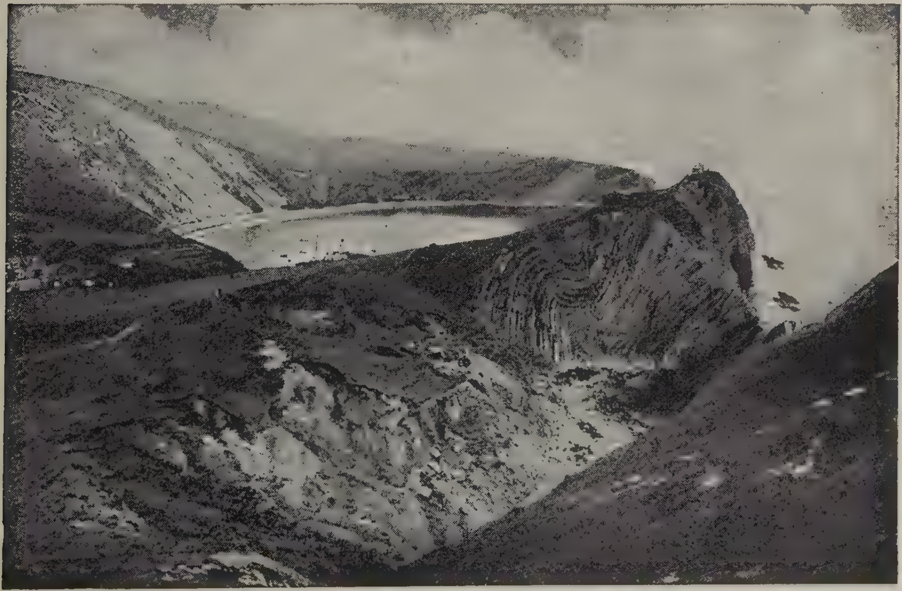
Gritstone is composed of sandstone in which the grains of sand are coarse and angular, so that the stone when broken feels very rough to the touch. *Greywacke* (Ger. *grau*, grey; *wacke*, a flint) is the name given to a very compact and hard grey sandstone, the hardened muddy sand of very ancient sea-floors. *Flagstone*, used for pavements, is a sandstone which splits into thin flags along the planes of bedding or stratification. *Freestone* is a sandstone which can be cut with equal ease in any direction.

Conglomerate, popularly known as 'pudding stone,' is a rock in which the sand is replaced by gravel or shingle, cemented together with hardened sand or clay or the cementing materials just mentioned. The rounded pebbles which give character to the conglomerate may be of quartz, granite, limestone, or many another rock, but siliceous or flinty pebbles are the most common. Conglomerates are known, therefore, as quartz-conglomerate, limestone-conglomerate, flint-conglomerate, etc.

Breccia (pronounced brech′ia; the word is Italian for a breach) is a rock in which the particles are angular. This suggest its origin, for while conglomerate points to the action of water, which always tends to round the particles exposed to its action, breccia indicates atmospheric action, cliff falls, and glacial débris—together with circumstances which have left the fragments much as they were when they were broken off and buried.

Clay. The argillaceous or clayey rocks are composed of fine argillaceous sediment derived from the waste of rocks, especially of granites and other rocks containing felspars as ingredients. Clay itself is a hydrated silicate of alumina, a product of the decomposition of felspar. It occurs in many forms, such as kaolin or china clay, pipe-clay, fire-clay, and the coarser brick-clay. Loam is a mixture of clay and sand. Loess is a clay accumulated by wind drifts. Boulder clay or till is a stiff sandy clay containing boulders of all sizes; it is found only where ancient glaciers once ground to powder all but the hardest fragments of the rocks that lay in their paths.

Under pressure of overlying strata ancient clays have hardened into compact rocks. Mudstone is the intermediate stage between clay and rock; it will not split, and is easily rubbed down into mud with the aid of water. *Shale* is any clayey rock which splits easily into thin layers; of the many varieties, mention may be made of oil-shales, from which paraffin is extracted. *Slate* is a hard and very ancient clay that has been folded and



LULWORTH COVE. This photograph of the beautiful little Dorsetshire cove shows very clearly the folded layers in the front cliff, composed of Portland sandstone. The white cliff at the back of the cove is chalk.
Courtesy of Great Western Railway

SLATE QUARRY IN N. WALES. *Slate is a metamorphic rock, that is, one produced from clay by great heat and pressure. In the process it becomes consolidated into cleavage planes, along which the slate splits readily.*

Photo, L.M.S. Railway

compressed; it splits into thin regular plates, in which the cleavage is quite distinct from the bedding. Shale and slate are examples of metamorphic rocks.

Limestone. The *calcareous* rocks, or limestones, consist mainly of calcium carbonate. They are largely organic, and chalk is the purest example—this being composed almost entirely of the shells and skeletons of organisms which became deposited in ancient seas. By far the larger number of limestones are of similar organic origin. Marble is a limestone which has been crystallized by heat, and is, therefore, a metamorphosed rock. The magnesian limestones or dolomites (so called after the French geologist, D. Guy de Dolomieu, 1750–1801) are calcareous rocks consisting of a mixture of calcium carbonate with magnesium carbonate. All limestones effervesce when acid is dropped on them, and may thus be easily recognized. A few calcareous rocks contain phosphate of lime, e.g. guano, bone breccia, coprolites, and phosphatic chalk.

Coal and Peat. The *carbonaceous* rocks have almost all been derived from the decay of vegetable matter. They play an important part in human life as the chief sources of heat and power. Peat is the most recent carbonaceous rock; lignite or brown coal represents a more advanced stage in the mineralization of vegetable matter, and occurs in strata more recent than those of the coal measures. Coal is a rock which contains as impurities 75 to 90 per cent of carbon with oxygen, hydrogen, nitrogen, sulphur, and many other elements. Anthracite (Gr. *anthrakites*, coal-like), the most completely mineralized form of coal, contains over 90 per cent of carbon, owing to so many of the volatile constituents having been expelled from it—probably by heat. Welsh steam coal is a form of anthracite. Petroleum (Lat. *petra*, rock; *oleum*, oil), which may be termed liquid rock, is also a product of decayed vegetation, and is classified as a carbonaceous rock. Graphite (Gr. *graphein*, to write) is practically pure carbon, and is found in beds, sheets, detached masses, in mica-schist, gneiss, and granite.

Silica. Siliceous sedimentary rocks are of organic origin, being produced from the shells and skeletons of marine organisms which used silica for their structure instead of lime. The most important of these rocks is flint, which consists of practically pure silica. It is found in nodules, usually in chalk strata; and is believed to be formed by chemical deposition of the silica of the dead sponges, diatoms, and radiolarians of the ocean.

Crystalline sedimentary rocks are uncommon. Rock salt, the best-known example, often assumes a crystalline structure, and is a relic of long-evaporated ancient seas or salt lakes. Travertine, or calc-sinter, is a crystalline form of limestone which has been dissolved in water containing carbonic acid gas and deposited in thin layers—successive deposits of which will build a mass of solid stone at the bottom of pools, streams and subterranean caverns.

Stalactites. Stalactites (Gr. *stalaktos*, a dripping) hang down from the roof of limestone caves; stalagmites (Gr. *stalagmos*, a dropping) rise from the floor. They are of similar origin but of different formation, inasmuch as the layers have been formed by carbonate of lime in solution filtering through the limestone rock and forming crystalline pendants and pillars of fantastic shape and wondrous beauty, such as may be seen in the famous caves at Cheddar in the Mendips (*see* Colour Plate facing p. 80).

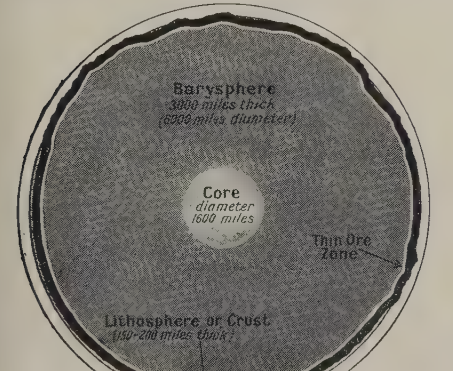
LESSON SIX

Primeval Rocks and Primitive Life

The Archaean rocks, whether igneous or sedimentary, are, as the name implies, the most ancient of existing forms, and are, therefore, usually the most deeply placed. Not always, however; for the crumpling up and folding of the earth's crust to form mountain ranges, together with long ages of denudation, have brought these oldest rocks to the surface in many parts of the world.

Below these Archaean beds is the *lithosphere*, or rocky crust of the earth, which protrudes here and there above the surface as plutonic or volcanic material. The depth and character of the lithosphere are still matters of investigation and inference, as is the interior of the earth generally. Professor J. W. Gregory thus describes it in the light of the most recent researches:

> The earth as a whole consists of a central core surrounded by five shells. The central core, about 1,600 miles in diameter, must be composed either of fluid or gas, for it does not transmit some earthquake waves that pass through any form of solid matter. This core is enclosed in a thick, hot, heavy shell, which is composed of native iron alloyed with nickel, and contains smaller quantities of other metals and of those constituents which form the ordinary rocks of the crust. This shell of nickel iron is about 3,000 miles in thickness, and therefore forms the main mass of the earth. From the weight of its material it is known as the barysphere or heavy sphere. It is kept rigid and solid by high pressure in spite of its intense heat.
>
> Above the barysphere lies a comparatively thin zone composed of a mixture of the metals of the barysphere with the earthy minerals that form the crust. This ore zone passes upwards into the rocky crust or lithosphere, which is probably from 150-200 miles in thickness. The material of the crust was formed as a slag by the lighter earthy materials of the barysphere floating upwards and thus becoming separated from the heavy nickel iron and its associated metals. The rocky crust consists of two chief groups of constituents: one group is made up of minerals which are light both in colour and weight, and form such rocks as granite. The second group includes more magnesia, lime and iron, and its rocks are therefore heavier and darker in colour; they are the chief source of the iron in the ores of the crust.



ARCHITECTURE OF THE EARTH. ***Five shells surround the earth's core: (1) the barysphere, composed mainly of iron and nickel; (2) the ore zone, in which the metal is mixed with earthy minerals; (3) the lithosphere or crust; (4) the hydrosphere; and (5) the atmosphere.***

Above the lithosphere is the hydrosphere, composed of the oceans, seas, lakes, the water of rivers and that which is absorbed in the rocks. The outermost gaseous envelope, which is now known to extend to a height of at least 500 miles, is the atmosphere.

Formation of Archaean Rocks. All these six divisions existed when the Archaean rocks began to be formed by their interaction—that is, by water, wind, and chemical agencies, followed later by organic agents. Exactly when organisms came into existence and life began to play its part in geological history is not known, because so much of the early strata has been destroyed by fiery upheavals or denudation. But traces of these earliest times remain in the Archaean rocks, in the thick beds of limestone and the masses of marble (metamorphosed limestone), and in the seams of graphite, which form the carbonized remains of early vegetation.

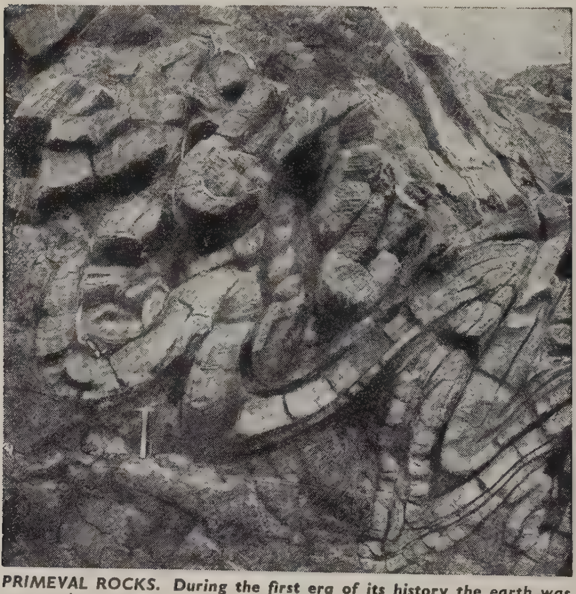
Thus palaeontology, the 'science of ancient beings,' begins in the Archaean rocks, and it covers the 1,200 to 1,500 million years during which, as it has been reliably estimated, life has existed on this planet. Palaeontology is divided into four eras. First comes the *Archaeozoic* or Pampalaeozoic, that is, the primeval era represented by the Archaean rocks. Then follow the *Palaeozoic* or Ancient Life era, the *Mesozoic* or Middle Life era, and the *Cainozoic* or Recent Life era, which bring the long record down to historical times. Fossils are found only in the last three eras—eras which are also known as the Primary, Secondary and Tertiary. Sometimes a fourth is postulated, known as the Quaternary and covering the more recent prehistoric ages and historical times up to our own period.

Metamorphic Beds. Owing to the various vicissitudes through which these primeval beds of stratified rocks have passed, they have lost their original character and have become metamorphosed, chiefly by heat, pressure, crumpling or crystallization through water and chemical agencies, into rocks and beds of an apparently different type. These are known as metamorphic rocks. Most Archaean rocks are metamorphic, but not all metamorphic rocks are Archaean, because many beds of much later ages have become metamorphosed and some may be undergoing the process at the present time. Thus it will be seen that the presence of metamorphic beds greatly complicates the sequence of strata, apart from the obliteration of fossils, which often occurs and thus destroys a possible key as to their age. Nevertheless, their position relative to other unaltered beds usually provides a solution.

Some metamorphic rocks may be transformed igneous masses, such as gneiss, which is pressed, distorted and foliated granite. A false stratification will sometimes be caused by pressure from above or the side, produced by foldings in the earth's crust due to shrinkage. For during this first era the earth was larger than it is at present, and its crust thinner. It was contracting comparatively rapidly, and just as the skin of an apple shrinks and is thrown into folds when the pulp dries, so the rigid crust of the earth became wrinkled and thrown into mountains. Thus the primeval rocks that were laid down as normal masses of igneous rocks, either plutonic or volcanic, or were deposited as sedimentary strata, were subsequently disturbed, tilted and bent to various angles and curves, pressed and baked by subterranean heat—which was then much nearer the surface—until they assumed the false stratification as shown in the illustration of folded rocks.

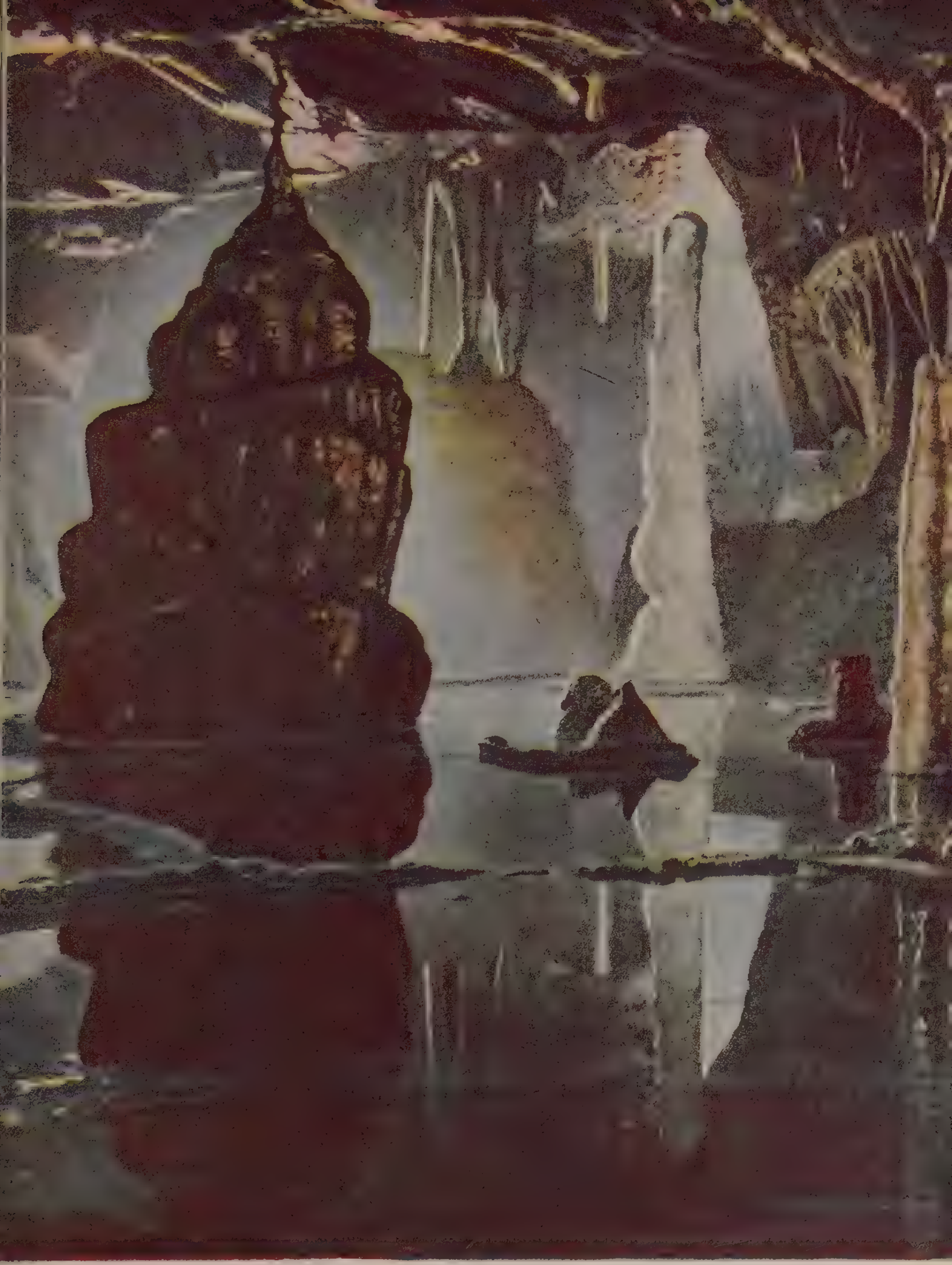
Good examples of metamorphic sedimentary rocks are marble and slate. The former, having been once limestone laid down probably by marine organisms, was then heated under great pressure and subsequently crystallized, on cooling, into marble. Slate is the mud of those ancient times which became solidified into sedimentary beds of clay; these were subsequently folded, compressed, subjected to heat and rendered partly crystalline, so that they split into slates at totally different angles from that of the original sedimentary layers. Fossils are frequently found in them singularly distorted, as were the strata. The argillaceous schists are a much more metamorphosed form of clay, which has been subjected to heat, pressure and possibly chemical action.

Metamorphic schists are almost as numerous as the sedimentary and igneous rocks from which they are derived. Thus, in addition to the above clay (or argillaceous) schist, there is quartz-schist produced from sedimentary sandstone and quartzite, a very hard crystalline rock, derived from



PRIMEVAL ROCKS. During the first era of its history the earth was contracting comparatively rapidly, with the result that its rigid crust was folded and wrinkled by the shrinkage of the barysphere, as is evidenced by the black slates and limestones shown here. When these were laid down in primeval times they were in horizontal strata.

Photo, Geological Survey and Museum



STALACTITES IN A CHEDDAR CAVE. Rich in colour and fantastic in shape, these stalactites (hanging from the roof) and stalagmites (rising from the floor) in Cox's Cave at Cheddar, Somerset, are the result of water filtering through the limestone roof. The carbonate of lime in solution crystallizes out as the water drops, and evaporates.

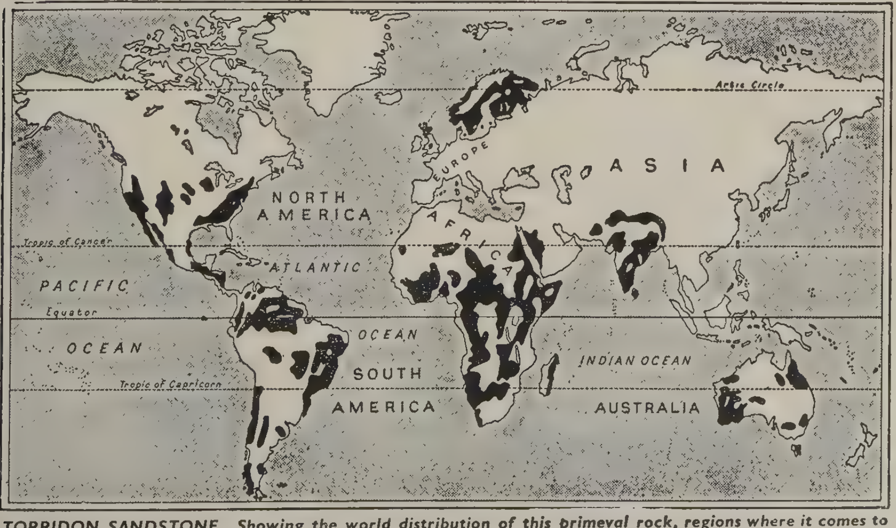
Photo, Valentine

ANCIENT SEDIMENTARY ROCK. *Sea cliff of inclined Torridon sandstone at Cailleach Head, Ross. This rock is composed of sand and pebbles, rounded and faceted by the action of primeval desert winds.*

Photo, Geological Survey and Museum

more completely crystallized sandstone. In schistose conglomerates the pebbles have been pressed into hard layers. Gabbro-schist and hornblende-schist are metamorphosed plutonic and volcanic rocks and, therefore, of purely igneous origin; whereas mica-schist, an aggregate of quartz and mica, often contains fossils which are evidence that it was once sedimentary rock.

Torridon Sandstone. Some of the primeval rocks of the Archaeozoic era escaped these metamorphic agencies and remained so little altered that they, in addition to the graphite seams and the beds of metamorphosed limestone, give clear evidence of life and the geographical conditions under which it existed. The most world-wide rock of this kind is a coarse-grained red sandstone which forms extensive areas in Scandinavia, North and South America, India, Australia, and Africa. It is well developed in north-west Scotland, from the Island of Skye northwards through the Torridon Mountains (whence this geological division is named); also in the Longmynd area of Shropshire.



TORRIDON SANDSTONE. *Showing the world distribution of this primeval rock, regions where it comes to the surface being marked in solid black. It takes its name from the Torridon Mountains in N.W. Scotland.*

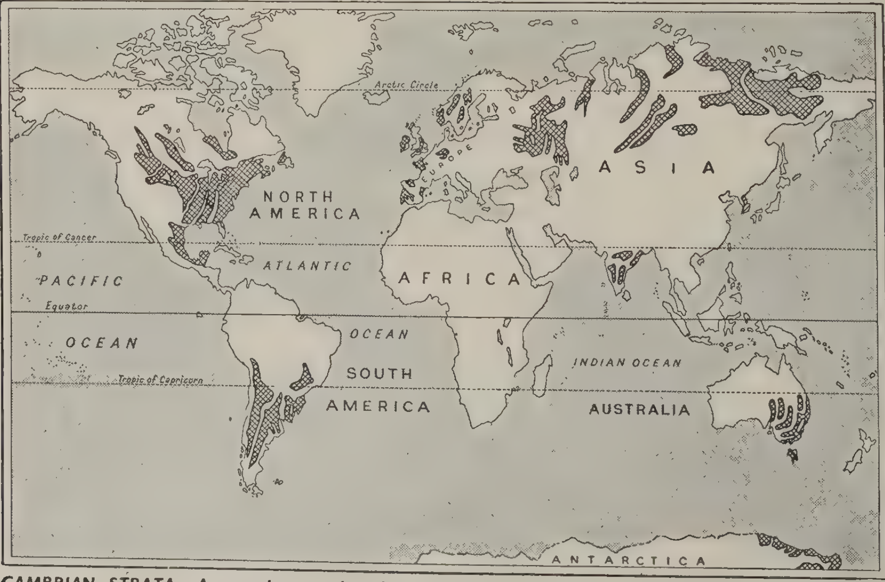
This primeval sedimentary rock is known as Torridon sandstone, and is composed of sand and pebbles, which bear evidences of the action of wind. There was an absence of turf as well as a scarcity of vegetation in those far-off times, and so loose barren sands would get piled up into strata, which in the course of many millions of years became cemented into the rock that has stood there for probably a thousand million years. This Torridon sandstone has yielded no definite fossils; that living beings were in existence is, however, proved by the fact that some grains of phosphate of lime containing grooves or canals undoubtedly caused by organic agencies have been found on examination of this sandstone beside Loch Broom, in Scotland.

LESSON SEVEN

Rocks and Fossils of the Cambrian Period

We now come to the Palaeozoic Era, which, being the first to reveal precise evidence of species in the form of definite fossils, is also known as the Primary. The Palaeozoic or Ancient Life Era is divided into six Periods: Cambrian, Ordovician, Silurian, Devonian, Carboniferous, and Permian. It must be remembered that these eras and the periods into which they are divided are more or less artificial divisions of a continuous but changing record; and though the existing strata which are the visible evidence of the periods are not always continuous, they follow a regular sequence.

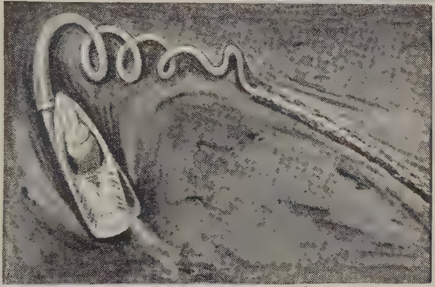
The various beds of rock composing the strata of the Cambrian Period (so called because the beds were first recognized to be fully developed in Wales—Cambria) follow those of the Archaeozoic Era. They are divided into the *Lower Cambrian*, *Middle Cambrian*, and *Upper Cambrian.* In Wales the *Lower Cambrian* is represented by the Caerfai beds of the St. David's area, among the oldest fossiliferous rocks in Britain, and by the Lower Harlech beds in North Wales. The *Middle Cambrian* is represented by the Solva or Menevian group and the Upper Harlech beds. The *Upper Cambrian* comprises 6,000 feet of Lingula Flags, including bluish and black slates and sandstones, together with 1,200 feet of the Tremadoc group of dark-grey slates. These strata have



CAMBRIAN STRATA. *Areas where rocks of the Cambrian Period are found throughout the world.*

been estimated to attain a thickness of 20,000 feet.

In England the Cambrian strata come to the surface only in small areas near Nuneaton, the Wrekin area of Shropshire, the Malvern hills, the Lickey hills in north Worcestershire, and the Lake District, where the beds are present as dark-coloured slates round Skiddaw and the Derwent and Crummock Waters. The greater part of the Isle of Man is covered with the famous Manx slates, together with the grits, shales, and flagstones of the Cambrian Period. Also in the Irish counties of Dublin, Wicklow and Wexford, Cambrian beds similar to those of the Manx slates exist. In Scotland the beds of the Cambrian Period come to the surface only in the extreme north-west, where they overlie the Torridonian sandstone of the Archaeozoic Era. They attain a thickness of about 2,000 feet, and are represented by fossiliferous limestone, Serpulite grit, quartzite and a thin bed of conglomerate. These beds indicate the very varied conditions which prevailed during each epoch of the long Cambrian Period.



LIFE IN THE CAMBRIAN PERIOD. In Cambrian mudbanks there lived innumerable shellfish like the brachiopods shown in the two lower illustrations: centre, a two-valved creature known as Lingula pyramidata and below, a crustacean. Top right, reconstruction of trilobites, crustaceans (now extinct) which were related to crabs and were the most characteristic of the Cambrian fauna.

On the Continent the Cambrian strata are present in Brittany, in the Ardennes district of Belgium, in Leon, Asturias, Galicia, Seville, and generally over the western districts of Spain and Portugal. In Norway, Sweden and northern Russia the Cambrian strata are presented as broad, flat deposits apparently but little altered by earth movements since they were laid down between 1,000,000,000 and 500,000,000 years ago. Throughout south-east Canada and in the United States east of the Alleghanies the Cambrian strata are extensively displayed, having a thickness of from 2,000 to 10,000 feet and lying remarkably flat and undisturbed, as in northern Europe, over the vast Archaeozoic beds, there estimated to be at least 50,000 feet thick. The Cambrian rocks crop out from under the Andes in Argentina; they appear in places as far apart as Korea, India, south-east Australia, Tasmania, and even South Victoria Land in Antarctica. Throughout all these areas the rocks are just as varied as in Britain, consisting of shales, slates, hard sandstones, greywackes, grits, quartzite, quartz-schist, mica-schist and lime-stone.

How do geologists know that all these strata, composed of such diverse material, were deposited in the Cambrian Period? The answer is that they can tell partly by the position of the beds relative to those above and those below; chiefly, however, by the type of fossils.

Cambrian Fossils. We have already seen that, in the Archaeozoic Era, vast beds of metamorphosed remains of animal and plant life exist in the marbles and graphite veins, limestones and sandstones; but it is not until we come to the lowest Cambrian beds that we find preserved relics of individual forms of life. Trilobites existed in such profusion that different species of them have been used to designate the Cambrian divisions, e.g. the Lower Cambrian is also known as the Olenellus, for in the beds comprising it the Olenellus trilobite has been found in large numbers. In the period when the beds of the Middle Cambrian were being deposited, the trilobite Paradoxides became paramount, reaching in some species a length of two feet. The Upper Cambrian has the more differentiated trilobite Olenus as a distinguishing fossil. These creatures, of which the nearest living representative is the king crab, attained such a degree of development during the Cambrian Period that it is often called the age of trilobites.

Though plant remains are scarce as individual fossils, the lower forms of animal life were plentiful. Brachiopods, in particular, both hingeless forms and the horny Lingulella, were so numerous that the name Lingula Flags has been given to beds which contain them. This genus—the oldest representative of the Lamp-shells or Brachiopods—still lives in modern seas. Brachiopods became more and more numerous as the Middle and Upper Cambrian times progressed. The bivalve shells of the Lamellibranchs included species akin to the modern mussel. The univalve Gasteropods had appeared in the Upper Cambrian and also Cephalopods, Orthoceras, and Nautilus, allied to the cuttlefishes, squids and paper nautilus of the present time.

The Echinodermata were much in evidence, beginning with the primitive Cystidians, from which all the genera and species of Echinoderm appear to have been derived. These flourished from the Lower Cambrian times until the Carboniferous, when they became extinct; but their allied types, the Crinoids or sea-lilies, were plentiful, together with star-fishes. The Medusae or jelly-fishes were present in the Middle Cambrian times; and the Annelids, the soft-bodied sea-worms which flourished in the Archaeozoic Era, must have been equally plentiful in the Cambrian times, judging by the surviving traces of their burrows and trails. Corals built up immense beds of limestone, as found in North America and in lesser degree in north-west Scotland.

Hydrozoa are represented by a variety of Graptolites of the Dendroid form in the Upper Cambrian, while there are many remains of early types of sponges. Radiolarians and other forms of Protozoa are in evidence, including the much-discussed Oldhamia and Serpulites, about which there is some doubt. The length of time that has elapsed since these creatures had the world more or less to themselves may be roughly estimated as at least 500,000,000 years; it may have been much more, for some geologists speak of a thousand million years. Nor do we know how long it endured or when it began, although, judging from the development of the fauna, it is often considered that this would have required a period as long as that which stretches between the Cambrian and the present day.

LESSON EIGHT

Ordovician Rocks and Fossils

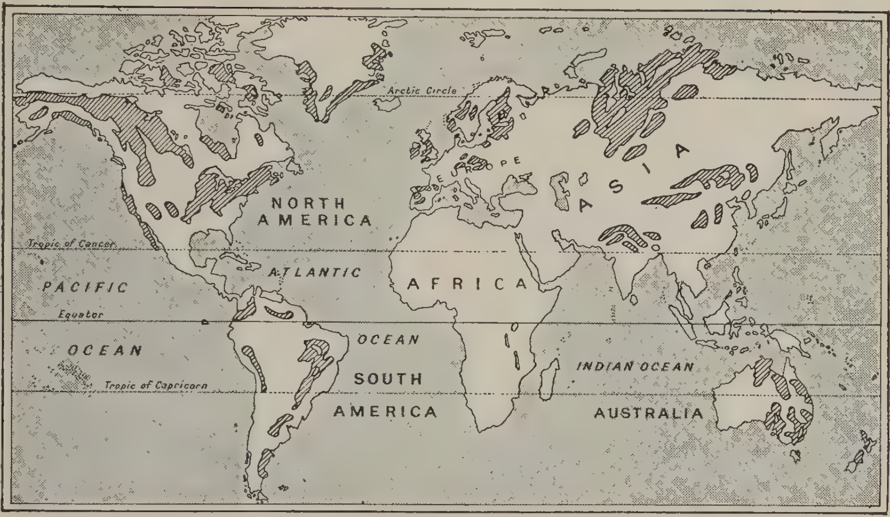
The rocks of the Ordovician period are named after an ancient British tribe, the Ordovices, who inhabited that part of Wales and the Border, now approximately the counties of Merioneth, Montgomery and part of Shropshire, in which the rocks were found by the pioneer geologists to be distinctively developed. It was the English geologist, Charles Lapworth, who coined the name, in 1879, and since then it has been adopted for rocks of the particular period.

The Ordovician strata reach a great thickness in some parts—15,000 feet in Galway and Mayo and 12,000 feet in the Lake District. They lie immediately above the Cambrian, of which they were at one time considered to form a part. The Ordovician period, in fact, was a continuation of the Cambrian, in which similar conditions prevailed, but with later and more highly developed forms of life than were present in the Cambrian. It was in the Ordovician period that backboned creatures first appeared.

It was a period of great volcanic upheavals and much subsidence and oscillation, during which vast quantities of sediment were deposited at the bottom of enormous seas and oceans. Thus were laid down the beds of strata composing the Ordovician rocks, many of them thousands of feet in thickness, composed usually of either grits, sandstones, conglomerates, quartzites, greywackes, shales or limestones.

The Ordovician rocks are divided into four distinct series: *Upper Ordovician* or Bala, known as Ashgillian and Caradocian; *Middle Ordovician* or Llandeilo, known as Llandeilian; Llanvirn or Llanvirnian; and *Lower Ordovician* or Arenig, known as Arenician. They are so called after the districts in Wales in which the particular series is exceedingly well developed. Since then they have been identified in much greater deposits in other parts of the world.

The Ordovician beds come to the surface and cover a large area in Wales, including



ORDOVICIAN PERIOD. *The world distribution of rocks of this Period is indicated by shading.*

the greater part of Carnarvonshire, a large district in Montgomery and Merioneth, the whole of Cardigan, most of Carmarthen and the adjoining districts of Radnor and Pembrokeshire.

In England they are not much in evidence at the surface except in south Shropshire, where they constitute a continuation of the Montgomery strata and attain a thickness of 10,000 feet. They are found on the western side of the Longmynd and on the eastern side in the Caradoc area. In Cumberland they compose all the mountainous region north-west of Ambleside and Coniston Water and, extending to Wastwater, combine with volcanic material to compose the grand mountainous masses of Scafell and the surrounding peaks. The Skiddaw slates and the whole area extending north, east and west of Keswick to beyond Crummock Water are Ordovician. In the Lizard district and in south Devon are contorted sedimentary rocks of Ordovician age.

In Scotland the Ordovician rocks exist chiefly in the southern uplands, extending in a belt from northern Wigtownshire to the Lammermuir hills. This belt extends across to Ireland, where it forms a succession of outcrops, attaining a grand development in Mayo and Galway. An obvious extension of the Welsh series spreads over Wexford, Waterford, Wicklow and Kildare. There is little doubt that Ordovician rocks are bedded under the greater part, if not all, of southern Britain and Ireland, and that they extend beneath the Irish Sea and the English Channel to Brittany and Normandy, where they are again much in evidence.

Ordovician Rocks Outside Britain. The north coast of Spain and other areas of the Iberian peninsula present Ordovician rocks of very similar description, attaining to a thickness of about 1,800 feet. In Bohemia it is estimated that they are about 3,000 feet thick. In the Baltic provinces of Germany, in Latvia, Finland, and throughout Scandinavia, they are extensively present, chiefly in the form of limestone which reaches a thickness only about 300 feet.

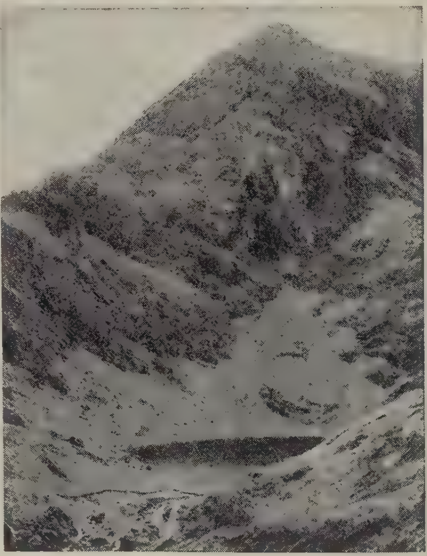
In North America the Ordovician period is well represented by strata containing fossils of trilobites, identical with those found in the British series; this suggests that Ireland and Scotland were linked up with a shore line across which is now the Atlantic in Ordovician times. Ordovician rocks occur over large areas of eastern Canada, the United States, and British Columbia. They are present, too, in South America, the south-eastern area of Australia, in Tasmania and New Zealand, in the northern Himalayas, northern China, Siberia and south Greenland.

Fossils of the Period. Throughout these wide areas the identity of each series of Ordovician rocks may be established by means of the fossils present. The most distinctive of these are the graptolites.

These have generally been preserved as *impressions*, some resembling quill-pens (hence their name), others fine filaments of seaweed or coral. They belong, however, to an extinct order of Hydrozoa, and were marine creatures, each encased in a small horny cell. The graptolite represents a colony or assemblage of individuals arranged, some species on one side of a single stem, some species on both sides. There were a great many varieties; some were curved, as the *Didymograptus* of the Llanvirnian series; others had many-branched forms, as the *Tetragraptus* of the Arenician series; the *Phyllograptus*, also of the Arenician series, had leaf-like forms, while the *Climacograptus*, of the Llandeilo and Bala series, was straight. Thus many distinct species of graptolites date, as it were, the successive divisions of Ordovician time.

Trilobites were also very plentiful, and, as in the case of the Cambrian period, particular species are identified with the strata of certain epochs. Most noteworthy are the trilobite *Illaenus* of the Bala series; *Ogygia buchi*, *Asaphus tyrannus* and *Agnostus* of the Llandeilian series; *Phacops* in the Llanvirnian series; *Trinucleus*, which had no eyes, in the Caradocian series, and *Ogygia Selwyni* in the Arenician series. These types were all very distinctive and of world-wide distribution.

The brachiopods, *Orthis* and *Strophomena*, were plentiful in the arenaceous deposits,



VOLCANIC ROCKS IN CUMBERLAND AND WALES. *Below is seen Scafell and its neighbouring masses. Scafell Pike, as the main peak is called, is the highest mountain in England (3,210 ft.) surpassing Helvellyn (see page 67), another witness in this area of violent volcanic activity in the Ordovician Period. At that time Wales was covered by the sea, and it was then that Snowdon (top right) was built up to an altitude many times greater than its present loftiest peak (3,560 ft.), which is a volcanic lava or ash cone.*

Photos, G. P. Abraham; S. G. B. Stubbs while corals and crinoids were abundant in the limestones; most plentiful were the now extinct Cystideans, twenty-three species having been found in the Bala series alone. Lamellibranchs were well represented by *Palaearca* and *Redonia* from the Arenician to the Bala series, together with numerous species of gasteropods, and the cephalopod, *Orthoceras*.

The most impressive find among all the fossil fauna of these times has been the discovery in the Ordovician strata of Colorado of numerous fish-like creatures possessing a backbone—the Ostracoderms. They have not been found in Europe, and, so far as is known, they are the ancestors of all vertebrates.

As regards the Ordovician flora, no individual fossils of terrestrial plants have, so far, been found, but a seam of anthracite at Olonets in Finland testifies to the existence of a prolific vegetation in favoured areas during this period.

Relics of Ordovician Volcanoes. In Britain the Ordovician age was one of great volcanic activity; in Carnarvon, Merioneth, and Montgomery the mountain ranges of the Arenigs, the great masses of Plynlymmon, Cader Idris and, greatest of all, Snowdon, are the denuded remains of this volcanic area. In Cumberland throughout the Borrowdale district, including the peaks of Scafell and Helvellyn, are masses of volcanic ash and lava which have been calculated to reach a thickness of 10,000 feet.

In Ireland volcanoes were active in the Dublin and Waterford areas, while in Scotland the region of volcanic activity was restricted to the southern uplands, more particularly the Girvan and Ballantrae areas of Ayrshire. Between this district and the Lammermuir hills in the east there was much folding of the strata and outpourings of lava and ash. The lava on reaching the sea produced the singular pillow-lava (*see* page 75) as a consequence of the sudden chilling. The evidence that these volcanoes belonged to Ordovician times consists in the existence of great sheets of volcanic ash and lava between the various beds of the Ordovician series; so distinct are these layers that it is possible in many instances to tell whether the volcanoes were active in, say, early Arenician or the very much later Llandeilian or, still later, Ashgillian times.

The Ordovician rocks provide the following commercial products: silver, zinc, lead, barytes, graphite, road-metal, flag-stones, slates, and quartzite for the manufacture of glass. Thus Man finds many uses for the materials that came into existence between, let us say, four and five hundred million years before his advent.

LESSON NINE

Strata and Fauna of the Silurian Period

The rocks representing the Silurian period were so named by Sir Roderick Murchison because the large area in central and south Wales where they are particularly prominent was once occupied by the ancient British tribe of the Silures. In addition to Radnor, Montgomery, and Denbighshire in Wales, the Silurian rocks are found at the surface in England in south Shropshire, in the Malvern hills of Worcestershire, in Herefordshire, in the Usk district of Monmouth, and over a large area of south Cumberland and Westmorland, enclosing both Windermere and Coniston Water.

In Scotland, the Silurian rocks only appear in the extreme south, where they constitute a broad belt some 30 miles wide, extending from the rocky coasts of Berwickshire, through Selkirk, Dumfries, Kirkcudbright and southern Wigtownshire, to the Mull of Galloway. Connecting beneath the sea, the Silurian rocks again form an extensive area in the Irish counties of Down, Armagh, Louth, Monaghan and Cavan, reappearing in small outcrops in Mayo, Galway, Tipperary, Limerick, Kerry and Waterford.

The Silurian strata are extensively developed in Scandinavia, particularly in the region of the Island of Gotland; for this reason the Silurian system is frequently referred to as 'Gotlandian' by Continental writers. Throughout Finland and in northern Russia it forms a belt extending to the Urals. In Poland, Bohemia, Germany, northern France, the Pyrenees and Portugal the Silurian rocks are found, though of no great thickness—usually under 1,000 feet—but in Scandinavia they reach 4,000 feet.

The Silurian rocks cover large areas in India, Burma, and western China; they also appear extensively in south-east Australia and New Zealand. In America they are present in the Appalachian Mountains, and in Pennsylvania, Michigan, Ohio, Illinois, Indiana, and throughout Ontario and the area north of the Great Lakes, even to Hudson's Bay and Greenland, while in the south they stretch from Brazil to Peru. Throughout all these areas the Silurian rocks are almost entirely composed of either sandstones, limestones or shales, while there is an almost complete absence of volcanic material of the period. From this we infer a cessation from the volcanic upheavals which were so characteristic of the preceding Ordovician times.

Strata of the Silurian Period. The Silurian period is divided into three successive series of strata, each representing an epoch. The uppermost and, therefore, most recent is noted first:

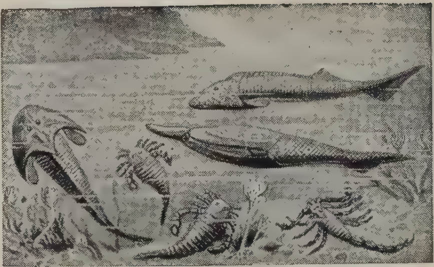
Downtonian or Ludlovian Series—represented by (up to 1,800 feet thick)	Ledbury Shales. Downton Sandstone. Upper Ludlow Beds. Aymestry Limestone. Lower Ludlow Shale.
Salopian or Wenlockian Series—represented by (up to 2,600 feet thick)	Wenlock Limestone. Wenlock Shale. Woolhope Limestone.
Valentian or Llandovery Series—represented by .. .. .. (up to 5,000 feet thick)	Tarannon Shale. Upper Llandovery. Lower Llandovery.

These thicknesses of strata apply solely to the above districts, whence they derive their names. In the Lake District the whole series attains a thickness of about 14,000 feet, and in Scotland 6,800 feet.

Borings indicate that the system lies beneath the superimposed strata of most of England, and extends south-eastward into France beneath the Channel. There these rocks stretch from Brittany to the Ardennes, while westward they lie beneath most of the superimposed beds of Ireland. Apparently dipping beneath the Atlantic, they reappear, in three corresponding series, in North America, where the Ludlovian series are known as the Salina, the Wenlockian as the Niagaran, and the Llandovery series as the Oswegan.

CORAL IN ENGLAND. *Indicative of the tropical conditions of millions of years ago is the coralline limestone found in various parts of England. The fossil coral shown above is from Wenlock Edge, Salop.*

British Museum, Natural History

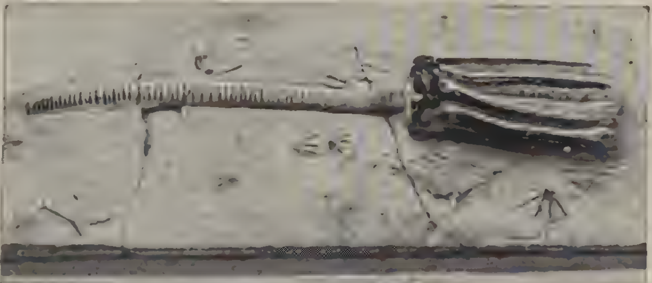


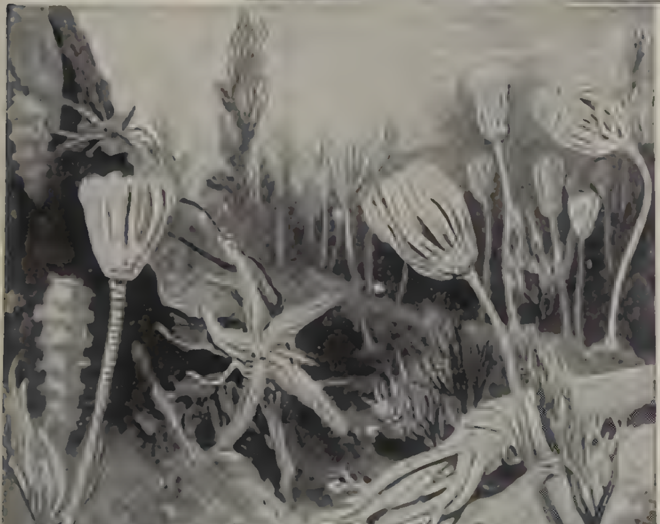
SILURIAN MARINE LIFE. *In this Period crustaceans developed to a remarkable extent, some attaining a length of 6 ft. In this reconstruction are examples of Eurypterus (bottom right), Pterygotus, and Pterichthys. The fish-like creatures above constitute a link between true fish and the crustaceans.*

Dominant Fossils. The identification of the beds of each series is assured by the presence of certain forms of fossilized life, as has been pointed out in previous Lessons in this Course. In the Silurian we find that very different species and types have appeared to serve this purpose, while the trilobites and graptolites still remain very similar to those of the preceding Ordovician period. These are still the dominant and most prolific fossils, but the graptolites now show the cells on one side of the stem only and are known as the Monograptidae.

The trilobites show a decided decline both in numbers and development; though *Phacops*, *Illaenus* and *Homalonotus* still abound, many Ordovician types have completely disappeared. The cause of this may have been the remarkable development of the much more highly organized crustaceans of the Eurypterid species, which in late Silurian times attained gigantic dimensions. The lobsters, crawfish and scorpions are their nearest modern descendants. The *Pterygotus* was the largest crustacean known ever to exist, reaching a length of six feet, while the *Eurypterus* attained 18 inches, and was so numerous that certain Downton beds are known as the Eurypterus shales. The fossil remains give indication that these great creatures crawled about in the shallow and muddy sea beds, where, close to the shore, they probably spread havoc with their powerful claws among the relatively defenceless trilobites. Thus through millions of years had these large crustaceans developed apparently from the humble little shrimp-like phyllopods of Cambrian times.

First Fossil Fishes. The earliest vertebrates, the fishes, were, however, soon to become a still more terrible menace to the teeming fauna of those Palaeozoic seas, and even the giant *Pterygotus* was ultimately to give place to them. The first appearance of fossil fishes in the beds of this country is found in the Ludlow series, in what is known as the 'Bone Bed,' which is full of the remains of fishes and Eurypterids. The fish-like creatures, the Ostracoderms, which had appeared in the Ordovician rocks of Colorado, are plentifully represented in the Silurian of Britain. One of them was the *Cephalaspis*, and another the *Pteraspis*. These, together with the *Scaphaspis*, *Auchenaspis* and *Eukeraspis*, although probably not true fishes, were a link between them and the crustaceans. The Ostracoda were entirely unlike any living fish or crustacean, but they showed structural affinity to the king crabs. The head and forepart of the Ostracoderms were protected by hard bony plates, and, while there were no limbs or paired fins, dorsal and caudal fins had appeared. Most important of all were the beginnings of the vertebral column; although this was probably not composed of true bone, it served as a support for the muscular tissue of a powerful tail, which would give the creature great mobility, and enable it to become an increasing menace to other forms of marine life, besides permitting unlimited growth when the head-shields were eventually abandoned and their descendants became true fishes.





LIVING GARDENS IN SILURIAN SEAS. During the Silurian Period sea lilies—not plants, but a species of starfish—grew in dense groves which, in the course of ages, have been compressed into beds of limestone. Above is a fossil sea-lily, while below is a reconstruction after Mr. Charles R. Knight.

British Museum

The Echinoderms attained their maximum development during the Silurian Period, both crinoids and cystideans composing most of the many massive beds of limestone. Corals also were in increasing abundance, and thus helped to build the thousands of feet of limestone that are now evidence of the enormous length of time which must have elapsed in the process—still continuing in southern seas.

Echinoids, or sea-urchins, first appear in the Silurian strata of Britain—*Echinocystis*, *Palechinus* and *Palaeodiscus* being the ancestors of a most prolific family, which has continued to present times. Starfish were also abundant, as were brachiopods of the Ordovician genera and the *Lingula* and *Orthis* of Cambrian times.

Lamellibranchs became much more abundant, and about 60 species of gastropods have been found in the Silurian strata of Britain alone, while numerous genera belonging to the nautilus family (now represented by only one living specimen, the pearly nautilus) had come into existence in Silurian seas. These had curved and coiled shells as distinct from the straight and often enormous cones of the *Orthoceras* species, which had continued from the Cambrian period, but were now declining in numbers.

Insects and Plants. Remains of insects have also been found in Silurian strata, together with numerous scorpions, which are almost identical with the present-day species; thus there must have been insect life for them to devour.

Plants are first found in the Silurian strata as individual fossils and distinct from beds of graphite and anthracite in which the fossil forms have been lost by age, pressure and probably heat. These, we have seen, were found in the oldest sedimentary rocks, but we have now *Nematophycus*, found in the Wenlock beds, as silicified stems, and *Pachtheca*, obviously seeds, as the first traces of plant life, which is hardly likely to be well preserved in a marine deposit, or over a period of time probably between 300,000,000 and 400,000,000 years, if not more. Traces of ferns and lycopods have nevertheless been found, while anthracite diffused through black shales bears witness to a considerable marine flora and possibly the periodical flooding of land areas.

Of the commercial products of the Silurian strata, minerals are not plentiful, owing to the scarcity of plutonic rocks, but veins of gold, silver and lead have been found in Britain, together with graphite in Cumberland. The hard limestones are valuable for building and road-metal, also for the production of cement.

LESSON TEN

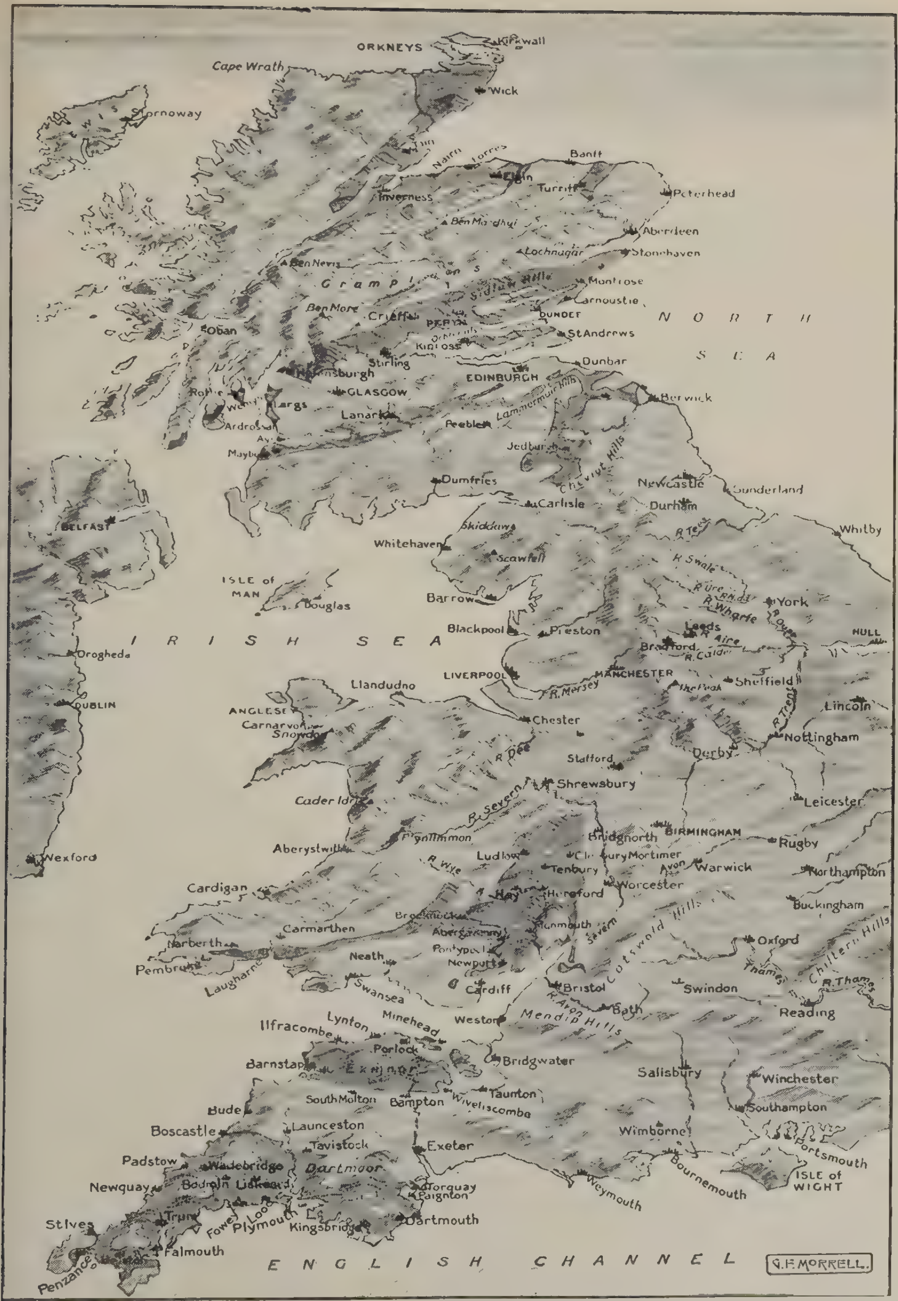
Devonian and Old Red Sandstone

The world-wide series of marine strata representing the Devonian period was so named by Sedgwick and Murchison in 1839 because of the distinctive fossils discovered in Devon and Cornwall. The same period of geological time is represented by lacustrine strata, known as the Old Red Sandstone. These are of special interest as revealing the former existence of three or, according to Geikie, four great and well-defined lakes that occupied most of the area between what is now the Bristol Channel and the Orkneys, with probable extensions far across the North Sea.

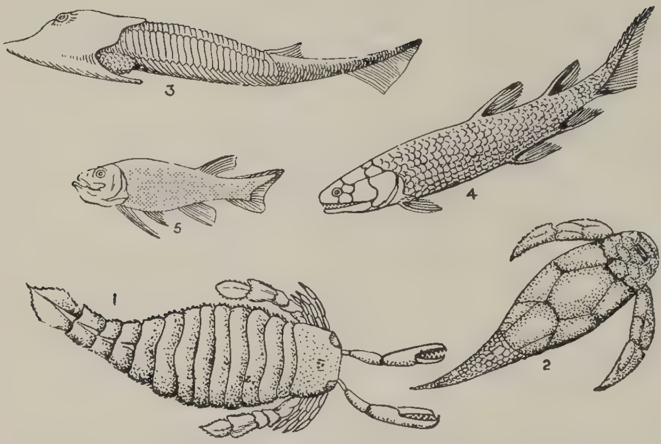
Over this wide area are found the Old Red Sandstone series of deposits with their peculiarly distinctive type of both rocks and fossils; these have little in common with the marine or Devonian series of deposits, which are world-wide in extent. That these two series existed contemporaneously is proved from the fact that they both overlie the Silurian and both are immediately below the Carboniferous, but neither the Old Red Sandstone nor the Devonian overlies the other to any extent; the stratigraphical evidence indicates that they were deposited under different conditions during the same period, generally known as the *Devonian System*.

The marine or Devonian series consists of shales, limestones, conglomerates, and grits reaching a thickness of about 8,000 feet in this country, where they are found at the surface only in Devon, west Somerset, and Cornwall. There they are disturbed and contorted, with much igneous material intercalated, thus indicating successive outbursts of volcanic activity. This marine series extends over a large area, beneath the superimposed beds, in southern England, having been found by borings under London and elsewhere. The Devonian rocks evidently continue beneath the Channel, for they cover a large area in northern France, and continue to the Harz mountains.

All this area was a vast sea; it extended southwards over Spain and Portugal and north Africa, while eastwards it covered the whole of southern Europe to central and north-eastern Russia, to the Urals and the Arctic regions, central Asia, and south China. It extended westward, evidently across what is now the Atlantic to the Great



DEVONIAN AGE. *Dark areas show where the Old Red Sandstone rocks come to the surface in Britain.*



THE AGE OF FISH. Following the Silurian Period true fish became abundant in the Devonian and Old Red Sandstone Periods, predominating over other forms of life. Devonian examples shown here are Pterichthys (2) and Cephalaspis (3), both armoured. Developments of the Old Red Sandstone are Pterygotus (1), a giant lobster or scorpion 6 ft. long; Osteolepis (4) and Acanthodes (5).

Lake district of Canada and the United States, where the Devonian rocks are extremely well developed and fossiliferous. In Cape Province and Natal, southern and eastern Australia, and the western states of South America, similar strata afford evidence of the existence of a great southern ocean in Devonian times.

In England and America the Devonian strata are divided into Lower, Middle and Upper, which are further subdivided according to the types of different localities. The fossils of the contemporaneous beds in America are similar to those in Europe.

Devonian Fauna. The marine fauna of the Devonian period, while generally similar to that of the Silurian, had certain marked differences. The graptolites had entirely died out. The trilobites were also on the decline and apparently much on the defensive, developing a spiny and very protective covering, as *Homalonotus*. Fishes, which had become very numerous and more varied, acquired still more the protective bone-like plates for the head and forepart of the body. *Cephalaspis*, *Pterichthys*, *Homosteus*, *Coccosteus*, and *Parexus* are notable examples of these protected marine fishes. The singular *Pteraspis*, which had appeared in the Ludlow beds of Silurian times, now became very prolific, but had retreated from that area, with the open sea to the Devonian Ocean farther south. Another, the great *Dinichthys*, had a headcase 3 feet in length. It is in the limestones and shales, not the sandstones, that the fossils are prolific. In the European area corals were less prolific than in Silurian times, thus pointing to possibly cooler conditions, or perhaps deeper waters.

The cephalopods had increased both in genera and species; while the great allied group, the *Ammonoidea*, which is now extinct, made its appearance in the new type, the goniatites. The brachiopods reached their greatest development, 1,100 species of these marine bivalves having been discovered in the Devonian strata.

Plant Life in Devonian Fossils. The Devonian flora is chiefly represented by ferns, *Knorria*, lycopods, club-mosses, calamites and *Palaeopteris*. While the conditions were not favourable for the preservation of plant life, it yet appears to have been very abundant in favoured localities, as in New Brunswick, Nova Scotia, and the Gaspé peninsula, where over 100 species of these flowerless plants, including club-mosses and pine trees, have been discovered. Also in the Alleghanies vast quantities of natural gas and oils, obviously due to decomposed organic matter, have been found in the fossiliferous Devonian shales. Insects were present, wings of the orders *Orthoptera* and *Neuroptera* being found impressed in the rocks.

The best areas for the study of these Devonian rocks and fossils are the coast line from Minehead to Ilfracombe, Combe Martin and, where exposed, on Exmoor; also Pilton, Chudleigh, Newton Abbot, Torquay; from Dartmouth to Plymouth and Polperro, Launceston, and the north coast of Cornwall to St. Ives; and from Penzance eastward along the coast.

The plant and insect life is associated rather with the estuarine deposits of the Old Red Sandstone facies farther north; these link up the Devonian marine with the purely lacustrine. There is stratigraphical evidence of a ridge of Old Red Sandstone rocks stretching eastwards from what is now the Bristol Channel to Belgium; this ridge separated the great Devonian Ocean of the south from the mountain and shallow lake area to the north. The sea had since Silurian times retreated southwards and left behind what appears to have been originally one large lake, but in the course of many millions of years there were many changes of level and shore-line, which are revealed by type of deposit. The Old Red Sandstone facies is, therefore, divided into Lower, Upper and Middle series.

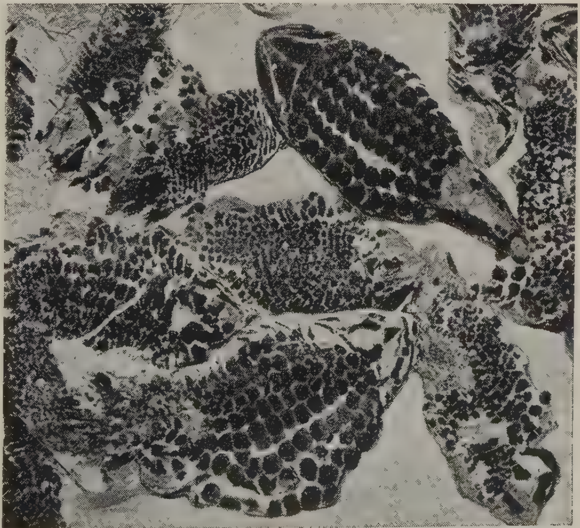
There was for long ages a gradual rising of the land above sea level, and great rivers brought down sediment from the mountains, spreading it out fanwise as sand, gravel and conglomerate in an ever-increasing deposition. Winds also added in many localities immense stretches of fine wind-swept sand, the products of disintegration, which covered areas left by the receding sea and drying-up lakes. The Upper Old Red Sandstone beds in Scotland are of a bright red colour and reach 500 feet in thickness.

Formation of Lakes. Four lakes appear to have ultimately formed, the most southerly being the 'Welsh Lake' revealed in Monmouth, Shropshire and Herefordshire, where the rocks are 7,000 feet thick. The great 'Caledonian Lake,' where the strata attained a thickness of 12,500 feet, was the most extensive; its basin filled the long synclinal folds of strata which stretched across Scotland and north Ireland in a south-west and north-east direction. It can be traced to the Sogne Fiord in Norway, and as far as Finland and Spitsbergen; while in the west it appears to have reached to Nova Scotia and the Gaspé peninsula, being revealed by the Old Red Sandstone rocks.

The immense amount of material which became deposited in the area of the great 'Caledonian Lake' was chiefly provided by the denudation of the crystalline mountain masses, rivalling the Alps in magnitude, which then formed a series of five great chains crossing Britain and Ireland and reaching to an estimated height of at least 12,500 feet. The present mountains are merely the denuded and glacier-worn stumps, which have survived at least 300,000,000 years.

The gradual filling in of the lake bed and rise of the land resulted in subdividing the vast waters, the northern division being known as 'Lake Orcadie,' while an arm of 'Lake Caledonia' to the south became 'Lake Cheviot.' Other lakes must have existed over the wide northern area, extending even to eastern Canada, to account for the vast fresh-water deposits of the Old Red Sandstone rocks; for no marine fauna or flora is found therein, no coral, seaweeds, or known denizens of the Devonian sea, except some Eurypterids and fish which, salmon-like, appear to have ascended the estuaries. Fish were very plentiful, most of them scale-covered; the *Osteolepis* and *Acanthodes* attained their greatest development, while the *Diplopterus*, *Glyptopomus* and *Asterolepis* were other examples.

Periodically, large areas of these shallow lakes appear in later times to have dried up, when the fishes crowded into the circumscribed areas and finally died in masses. Thus they are found as fossils in various places. Most remarkable was the *Dipterus*, which tried to escape these consequences, as does its solitary modern representative,



HOW DEVONIAN FISH DIED. In the Devonian Period desert conditions spread, lakes and rivers dried up, and fish from large areas were crowded into pools, where they died when the water finally disappeared. The geologist finds them packed close, as in this fossil slab from an Old Red Sandstone stratum.

British Museum, Natural History

the mud-fish or *Ceratodus* of Australia, which can survive temporary droughts.

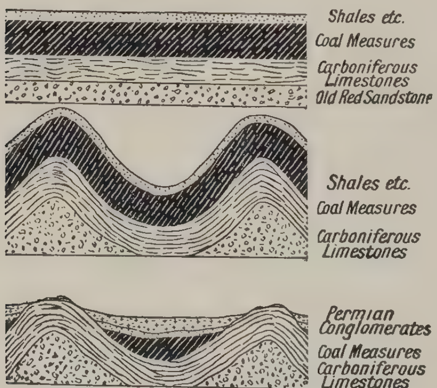
The Eurypterids were another remarkable type, which from their powers of migration, like crabs, were able to attain their greatest development in this age. The *Pterygotus*, like a giant lobster or scorpion, to which it was closely allied, continued to flourish from Silurian times, still attaining six feet in length and being equally at home in salt or fresh water.

Subsequently, much of this land began to sink and the sea encroached; the great beds of limestone began to be formed which now comprise the Carboniferous limestone constituting the base of this great age of plants. It is probable that the Devonian period represents an age upwards of 200,000,000 years ago. Many of its products have much economic value. The Old Red Sandstones and limestones furnish good building material; roofing slates are provided in Devon and Cornwall and the tin-stone in Cornwall; while lead, copper and iron ores are obtained in central Europe and road-metal from the intrusive granites.

LESSON 11

Deposits of the Carboniferous Sea

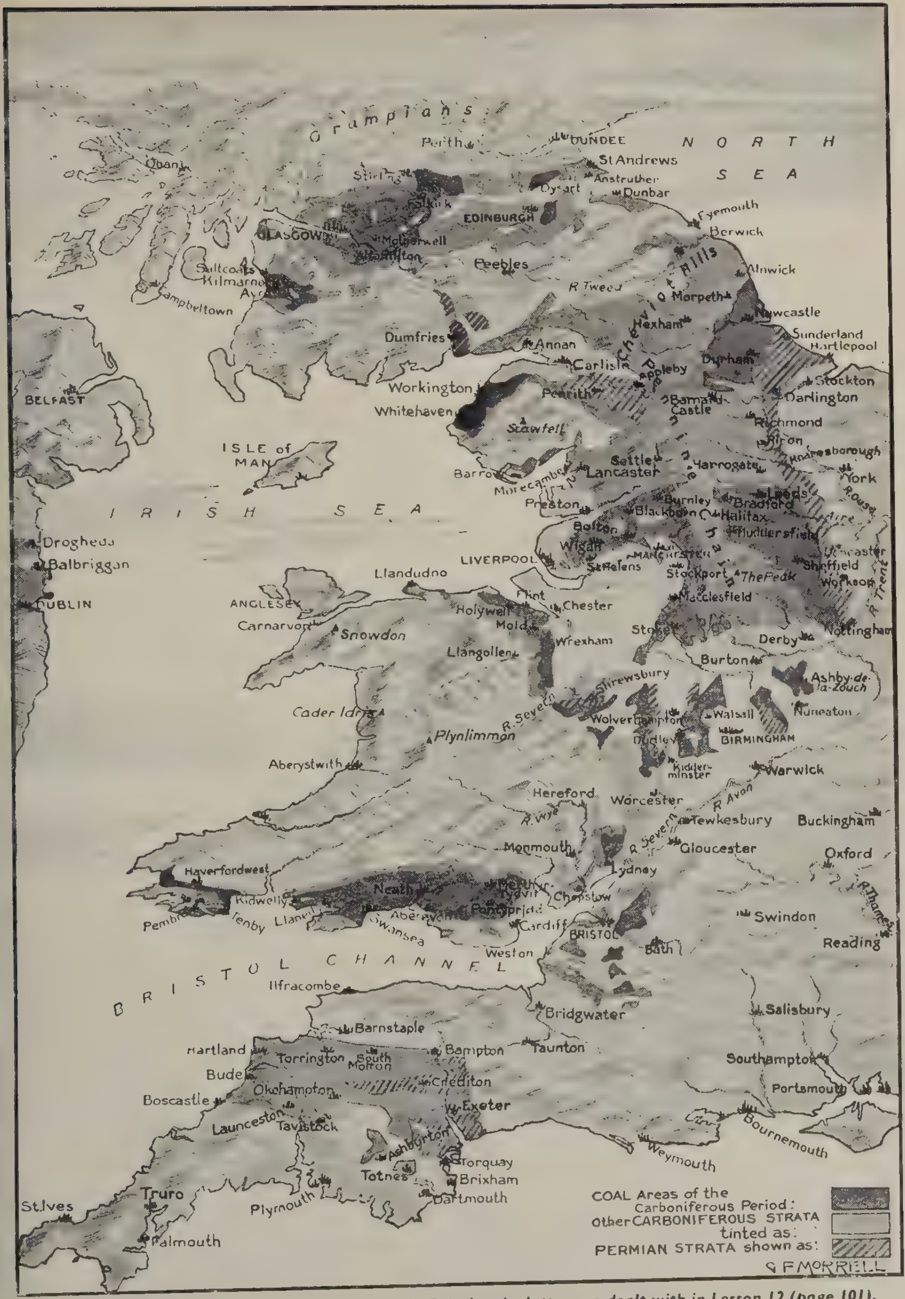
The Carboniferous period covers an immensely long era in the earth's history. Although the name is derived from *carbo*, Latin for coal, and was given because of the numerous coal beds laid down during the period, these form but a small proportion of the whole system, which, comprising limestones, shales, sandstones, and bands of ironstone, attains a thickness in many areas of 20,000 feet. The character, or *facies*, of these rocks shows that the Carboniferous period is represented by a marine and a terrestrial series of beds, together with estuarine and freshwater types. There are also intercalated layers of volcanic material which bear witness to successive eruptions in certain areas.



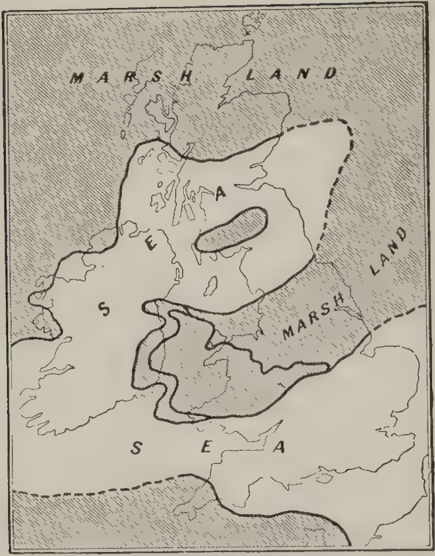
HOW BRITAIN'S COALFIELDS WERE SAVED. *When at the end of the Carboniferous Period the earth's crust became folded into ridges, most of the coal measures were subsequently lost through denudation and only those preserved that lay in the pockets of the hills. These were covered again later.*

The whole has been divided into *Lower Carboniferous* and *Upper Carboniferous*, with further subdivision into Carboniferous limestones, Yoredale beds, Millstone Grit beds, and the Coal Measures. The lowest beds of the entire series are the lower limestone shales, which also contain layers of sandstone and Carboniferous slate. Above these are the great beds of Carboniferous limestone, which are, of course, marine, and composed largely of corals, crinoids and foraminifera. These beds are overlaid by the upper limestone shales—generally known as the Yoredale beds—which contain bands of radiolarian chert, and are also marine. The next series is the Millstone Grit beds, composed of hard siliceous rocks with bands of shale, sandstones and flagstones. Occasional seams of coal indicate the beginning of the forest era and terrestrial conditions. They form, generally, the foundations of the Coal Measures, and contain remains of terrestrial plants. These beds were apparently deposited in the deltas of rivers, lagoons and shallow waters, constituting the beginnings of the extensive swamps in which flourished the prolific vegetation more particularly associated with the Carboniferous period. The fourth and last series, the Coal Measures, consists of sandstones, shales and clays, with numerous seams of coal in successive layers (some of great thickness), together with bands of ironstone.

The entire Carboniferous system is well developed in Britain, where the beds lie flat, except that the one-time continuous sheet of strata is now divided into synclinal troughs of basins by subsequent foldings. The chief of these folds are the Pennine, extending north and south, together with



CARBONIFEROUS AND PERMIAN STRATA *in Britain; the latter are dealt with in Lesson 12 (page 101).*



BRITAIN IN CARBONIFEROUS TIMES. The Carboniferous was a period of marsh-lands wherein swamp-forests rioted. During its later phases the peninsula (obliquely ruled) stretching across England subsided, leaving an island at its extremity. The island in Scotland was volcanic.

After Jukes Brown, ' Building of the British Isles '

the Hercynian, extending from the west of Ireland through southern England to Westphalia. Thus great and lesser basins were formed which preserved large areas of coal-bearing strata from denudation in later times (*see* diagram in page 94).

Carboniferous Sea. Following the Devonian period came a long era of gradual subsidence over southern Britain and Ireland; much of the Old Red Sandstone area was submerged, and in the clear waters of the warm sea, organisms lived and died, their shells, bodies and skeletons combining to build up at the gradually sinking sea-bottom a great bed of grey Carboniferous limestone, which in places reached thousands of feet in thickness. The sea first submerged the south of England and Ireland, extending northward over a ridge which, in the early part of the period, had formed an island where are now the Midlands. It extended, finally, to southern Scotland, where the sand and clay washed down from a great northern continent formed layers of sandstone and shale. A large volcanic island then existed over the Galloway region of Scotland and south of the Clyde; Derbyshire was also volcanic about this time, together with the Isle of Man and south-west Ireland.

These convulsions appear to have accompanied a gradual rise in the land; the sea became shallow and filled with sediment destructive to the corals, crinoids and other limestone builders, and shales were deposited instead. The Carboniferous sea, shown approximately in the diagram, was thus slowly filled up by the deposit of such sediments, together with sands and, finally, clays. Deltas and swamps formed at the mouths of great rivers, one in particular covering northern England and another Devonshire. These formed the deposits known as Millstone Grit, which contain a few marine fossils and a few land plants, but much detritus, angular fragments and much terrestrial material mixed with impure limestone. Bands of shale reveal flood periods or alternate rising and falling, while ripple marks and current-bedding indicate the flow of shallow water in one direction. Then terrestrial vegetation began to get a hold in these great semi-tropical swamps. It decayed while more grew, and so the beginnings of thin seams of coal appeared in this Millstone Grit (which also appears in the upper Carboniferous strata). Further building up of the land by denudation of the mountainous regions to the north favoured the growth of vast forests, the great Coal Measures being the result.

British Mountain Limestone. The Carboniferous limestone was originally known as ' mountain limestone,' because it composed so many of our English mountains, such as the Pennines, the Peak and the Mendip hills. It may also be seen well exposed in the gorge of the Avon near Bristol, in the Cheddar cliffs, and the crags of Derbyshire. In South Wales the thick beds of this limestone may be observed along the cliffs from the Mumbles to Worms Head, and in the St. Gowan's Head district near Tenby. Throughout the Pennine area of Yorkshire, Durham and Westmorland, together with a large part of Northumberland, this ' mountain limestone ' approaches the surface, and in the Lancashire Pennines it attains the immense thickness of 6,000 feet. In Scotland it covers a large area of the Lowlands from Ayrshire to Haddington, extending over most of Fife, while it is also well displayed at Burntisland and elsewhere along the coast. No trace of it is found north of the St. Andrews area, from which it appears that here was the farthest extent of this Carboniferous sea. The Carboniferous limestone is most extensively presented in Ireland, where it covers

15,000 square miles, and attains a thickness of over 2,000 feet. The lower limestone shales upon which these beds rest are well exposed over a large area of northern Mayo, and in the south of county Cork. In addition, there are the upper limestone shales, also known as the Yoredale beds. These overlie the 'mountain limestone,' and are well developed at Yoredale, in Yorkshire; they also cover the Pendleside area in Lancashire and merge into the Pennine limestone.

These complete the purely marine series of the Lower Carboniferous. The Millstone Grit series and the Coal Measures, constituting the Upper Carboniferous, are considered later.

The great Carboniferous sea, with its thousands of feet of marine deposits, was not peculiar to Britain. These deposits extend across northern France to Belgium, where in the Meuse area they attain a thickness of 2,500 feet. Thence they continue through south Germany and Bohemia to Russia, whence they stretch across Siberia to northern India, China, Japan and Alaska. In North America they cover an area of about 200,000 square miles. In Australia the Lower Carboniferous attains a thickness of 11,000 feet of shale, sandstones and limestone.

Fossils of the Lower Carboniferous. A remarkable circumstance is the similarity of the fossils throughout this vast area—the Australian, for instance, being identical with those found in Britain; this applies also to the land plants of the Upper Carboniferous. Obviously, it was a very warm period of the earth's existence.

The fossil remains in the Lower Carboniferous series are, of course, marine; in most genera they resemble the Devonian. The most prolific were the foraminifers, more particularly *Fusulina*; corals, chiefly rugose types; while the crinoids were so numerous that their remains produced beds of limestone hundreds of feet thick, known as crinoidal limestone. The genera chiefly represented are *Platycrinus*, *Actinocrinus*, *Cyathocrinus* and *Granatocrinus*. Brachiopods were plentifully represented by *Spirifer*, *Productus*, *Rhynchonella* and *Terebratula*. Polyzoa were very numerous and beautiful. Among the cephalopods, *Orthoceras* and *Actinoceras*, *Nautilus* and the ammonites (*Goniatites*) were the most numerous.

Trilobites had, however, greatly declined, being represented by the small *Phillipsia*, *Griffithides*, *Proetus* and *Brachymetopus*. The family of trilobites practically ceased to exist in the Carboniferous period, while the eurypterids greatly declined. The gastropods continued to flourish, *Bellerophon* and *Euomphalus* frequently appearing. Fishes became very numerous, judging by the number of teeth and spines which are found, particularly of the ganoid or shark type; they were of immense size. *Orodus*, *Psammodus* and *Petalodus* were the most noteworthy. The outstanding event of the long Carboniferous period, which probably goes back to between 100,000,000 and 200,000,000 years, was the first appearance of amphibians. These will be considered with the Upper Carboniferous series.

The chief economic products of this series are limestone for building and the production of lime and sandstones for making glass. Oil is distilled from the cannel and oil shales which exist south and west of Glasgow. Iron ores, lead and zinc occur in veins and pockets in the limestone.

CHEDDAR CLIFFS. Carboniferous limestone composes many English mountains and is well shown in the cliffs lining the famous 'gorge' at Cheddar, Somerset. Within these cliffs are remarkable stalactite caverns (see Colour Plate facing p. 80).

Photo, Dixon Scott

Upper Carboniferous. This series of strata has preserved for us the first extensive record of terrestrial conditions as distinct from marine. Large continental areas of dry land unquestionably existed before the Carboniferous period, but the system of deposition was not favourable to its preservation, as was the marine, since it consisted largely of blown sand and detritus, such as would be easily removed by denudation at a later period.

Circumstances more favourable to the preservation of the terrestrial deposits of the Upper Carboniferous, more particularly the Coal Measures, prevailed at this time. The great thickness of the deposits, together with the hard facies of the coal seams and their frequent situation in synclines between ridges, have saved for our use the most valuable of sedimentary rocks.

IN A CARBONIFEROUS FOREST. *Luxuriant forest-growth marked the Carboniferous period. In the course of ages the fallen trees, subjected to enormous pressure, were transformed into coal.*

Millstone Grit. Below the Coal Measures and constituting the lower series of the Upper Carboniferous facies are the beds collectively known as the *Millstone Grit*. These consist of hard compact siliceous strata, flags and sandstones together with beds of conglomerate composed of detritus and denuded fragments of granitoid rocks from the great mountain ranges of earlier geological periods, which then extended across Scotland and what is now the North Sea to Scandinavia. Occasional thin seams of coal occur, while in places beds of impure limestone alternate with beds of shale and with clear evidence of current bedding indicating that they are largely estuarine or river-formed; doubtless they were laid down in the huge deltas that had existed from Devonian times, as described in the preceding Lesson.

Millstone Grit is locally known as 'Farewell Rock' in South Wales and elsewhere, since it forms the base of the Coal Measures, and it is usually farewell to any further seams as soon as it is reached. It covers a large area of north Devonshire and Cornwall, from Tiverton to Bude, there being no Coal Measures overlying it in this district, or the countryside would wear a very different aspect. The rocks may be observed along the coast from Clovelly to Boscastle, where they are replaced by Devonian. Millstone Grit also forms the high moorland regions of west Yorkshire, being well exposed in the crags at Ilkley, at Pateley Bridge, also in the Harrogate and Keighley districts and over the Glossop area north of the Peak. These rocks also approach the surface between Lancaster and Settle, and protrude through the Coal Measures farther south. They provide paving stones and silica stone for fire-bricks.

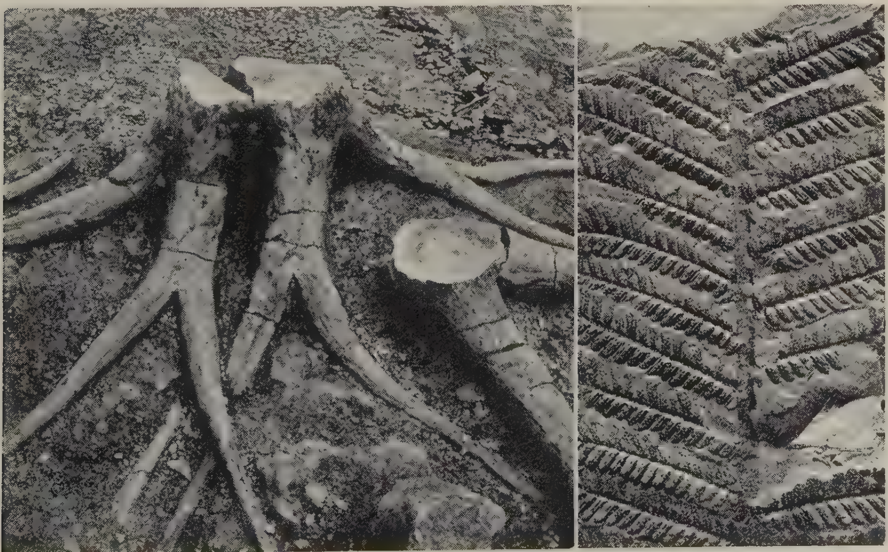
Coal Deposits in England. The Coal Measures exist in numerous basins throughout Britain and Ireland. The beds consist chiefly of shales with lesser beds of sandstone alternating with seams of coal, bands of fireclay and ironstone. The Coal Measures attain their maximum thickness in South Wales, where they are estimated to reach nearly 10,000 feet in some places, though generally they are much less than this; there are altogether about twenty-five seams of coal. In Lancashire they reach 8,000 feet in thickness and contain about sixty-five seams of workable thickness. In north Staffordshire there are about forty workable seams in beds estimated to total 5,000 feet. In Durham there are about sixty seams of coal in beds 2,000 feet thick. Leicestershire has ten seams of coal in beds about 1,500 feet thick. In Northumberland over a wide area the beds are between 2,000 and 3,000 feet thick and contain fifteen workable seams of coal. In Derbyshire they are about 2,500 feet thick, in south Yorkshire and Nottingham about the same—all being part of one great coalfield, which once linked up with the great coalfield of Durham and Northumberland. In the Whitehaven area of Cumberland the beds are about 1,500 feet thick. In the Forest of Dean are fifteen workable seams in beds about 2,500 feet thick. The Bristol and Somerset Coal beds are about 6,500 feet in thickness.

In Scotland, the Lanarkshire Coal Measures are about 4,000 feet thick and contain fifteen thick workable seams of coal. Others are in Ayrshire, near Edinburgh, in Haddington, Clackmannan and Fifeshire, where they reach nearly 1,000 feet in thickness. Cannel coal and oil shales are present near Glasgow. In Ireland the coalfields are very poor, though they are present over large areas of Kerry, Clare and Limerick, Leix and Kilkenny in the south, with smaller areas in the north.

Coal Throughout the World. On the continent of Europe the greatest development of the Upper Carboniferous facies is in Westphalia, where the whole series attains a thickness of about 11,000 feet, the lower 3,000 feet—known as the Flotzeere sandstones—taking the place of the Millstone Grit of this country. The upper 8,000 feet consists of Coal Measures in which as many as ninety seams of coal are present, about sixty of them being seams of good coal. This series reappears in the Mons and Douai areas, thinning out through the Boulonnais region of northern France and extending to Kent, where at a depth of over 1,000 feet not very productive seams are worked. It is considered probable that these continue westwards to the coalfields of Somerset and Gloucestershire. A remarkable feature of these beds is the faulted and consequent great displacement; older rocks frequently are superimposed by overthrust faults and so make coal-mining uncertain through the seams vanishing.

The great development of the Westphalian area has resulted in the name Westphalian being given, on the Continent, to the strata represented by the Upper Carboniferous in Britain. There are, in addition, certain uppermost Carboniferous beds absent in Britain, but well developed in northern France, where they are known as the Stephanian, and in eastern Russia as the Uralian.

The Coal Measures in the United States are the most productive and easily worked in the world; this is largely owing to the



PETRIFIED VEGETATION OF LONG VANISHED CARBONIFEROUS FORESTS. Generally speaking, coal was formed from dead vegetation; but where it resulted directly from forest growth, fossil roots are sometimes discovered embedded in the ground beneath and attached to trunks that grew up through the coal seam, as at Clayton, near Bradford (left). Often, too, by a happy accident, the undergrowth of ferns has preserved a record of its structure by leaving impressions in the surrounding material (right).

Photos, Geological Survey and Museum

great thickness of the seams. They are of great extent in Pennsylvania, Ohio and Illinois. Canada has also its coalfields in Nova Scotia, There are deposits in South America awaiting development,

In India and Australia the Coal Measures are proving highly productive. In the New South Wales area, where the Upper Carboniferous merges into the Permian, the strata, intercalated with good coal seams, attain a total thickness of from 11,000 to 13,000 feet, extending over a known area of 25,000 square miles. South Africa has also revealed Coal Measures which are being rapidly developed.

The Coal Industry. Outside the British Empire, China possesses coalfields rivalling those of the United States, although production there is delayed owing to the lack of up-to-date machinery. Elsewhere, Japan, the Donetz district of U.S.S.R., the Polish coalfields of Silesia—where the coal lies in seams varying from six to 24 feet thick, at no great depth from the surface—and those of Bohemia-Moravia, together with the undeveloped coalfields in the Arctic regions, offer the most promise, in addition to those already referred to. Italy and Spain are poorly provided in this respect.

The table below gives an idea of the annual production of coal (including lignite) before the war. The figures (except for Germany and Japan) are for 1938:

Country	*Total production in tons*
U.S.A.	450,000,000
Germany (1937)	362,000,000
U.K.	227,000,000
U.S.S.R.	133,000,000
France	47,000,000
Japan (1935)	37,000,000
Poland	37,000,000
Other countries (about) ..	207,000,000
The World (about) ..	1,500,000,000

In value this colossal amount of coal is worth more than twice that of all the metallic ores, including iron and gold, together with diamonds and other precious stones, put together.

Immense wealth, therefore, still remains buried in the coal seams, but the supply is not unlimited. For instance, in Great Britain the coal production for the year 1851 was estimated to be 55,000,000 tons; now it reaches to nearly five times as much, and produces an annual income of between £150,000,000 and £200,000,000, on an average.

Various estimates of the reserves of coal available in Great Britain at depths above 4,000 ft. below the surface have been made. The Royal Commission on the Coal Supplies of the United Kingdom in its final report issued in 1905 gave the figure as just over 100,000 million tons in proved coalfields, 40,000 million tons in unproved. Sir Aubrey Stevens in 1912 gave a total figure of nearly 179,000 million tons; the report of the International Geological Congress of 1912, issued in 1913, gave nearly 190,000 million tons; while Prof. H. S. Jevons in 1915 gave 197,000 million tons.

Now divide even the largest of these estimates by the present annual production, and we see that Britain's coal supplies, upon which so much wealth and prosperity depends, will last for only a few centuries, even assuming that there is no increase in consumption. Although other forms of fuel and power would help to reduce the necessary output, the ascertained facts point to the necessity of economy in the use of this limited source of wealth. If, however, we consider the world's reserves as a whole, it is estimated that there is sufficient coal to last at least 2,500 years, even if fresh coalfields are not found.

Carboniferous Flora and Fauna. The Coal Measures are rich in fossils of terrestrial flora, and even fauna, for the forests provided the food and shelter for numerous land creatures, while the mud of the marshy lagoons and deltas preserved their remains. Scorpions such as *Eoscorpius*—a small terrestrial descendant of the great Eurypterids of earlier geological periods—were in existence, and insect life attained enormous development; 1,300 specimens of ants, cockroaches, crickets, dragon-flies, may-flies and locusts, together with great plant-eating millipedes, and beetles, have been collected in one locality where, conditions permitting, the preservation of their fossils existed. Wings of insects reaching to seven inches in length have been found; also evidence of creatures with a wing-span of over a foot. It was the age of insects, for their arch-enemies the birds had not yet made their appearance. Not for many millions of years were birds evolved (*see* the Archaeopteryx, p. 113).

First Four-Footed Creatures. Most impressive of all was the first appearance of four-footed creatures, the amphibians. These belonged to a long extinct type, the labyrinthodonts (named from the labyrinthine folds in their teeth). They were similar in many respects to the existing salamanders, which are doubtless their descendants. Thirteen genera of these amphibians have

FIRST CREATURES WITH LUNGS. During the Carboniferous Period a warm, moist climate prevailed. Fish, forced to evolve by the preceding Devonian drought, developed lungs and limbs and so became the first amphibians, but were still mostly restricted to water. Some, however, passed on to the land to become reptiles.

been discovered of this Carboniferous Period in Britain, the *Anthracosaurus*, *Loxomma*, *Urocordylus* and *Ophiderpeton*, together with the *Archegosaurus*, in Prussia, having attained considerable development even at this early period. They were from three to twelve feet in length, partly protected by hard fish-like scales, and doubtless fed on crustaceans and lowly forms of insect life, which abounded.

The flora was prolific, lycopods or club-moss types, having trunks reaching to 60 feet high, lepidodendrons and ulodendrons being most in evidence. The *Equiseta*, or horsetails, are represented by *Calamites*, the jointed stems, and *Asterophyllites* and *Annularia*, which are varieties of this plant's foliage. Numerous ferns, *Neuropteris*, *Sphenopteris*, *Pecopteris* and *Odontopteris*, existed, together with pteridosperms. Many of these types were great tree-ferns, which shared these vast forests with immense trees, whose fossil trunks are known as *Sigillaria*, and their root stems as *Stigmaria*. Conifers and araucarias grew in dense abundance. Their fossil remains include seeds and seed pods, thus exhibiting the minutest details after a lapse of at least a hundred million years.

LESSON 12

Chief Features of the Permian Period

The Permian is the last of the Palaeozoic periods; its strata follow the Carboniferous, and were originally known as the New Red Sandstone, in contradistinction to the Old Red Sandstone of the Devonian Period, which immediately underlies the Carboniferous. Since several other formations, such as marls, breccias, limestones, dolomites and conglomerates, also enter into the composition of this geological period, the name Permian was proposed by Sir Roderick Murchison in 1841. It is derived from Perm, the old province of east Russia where these deposits are found extensively developed.

In Britain there exists a distinct break between the Upper Carboniferous and the Permian series. The highest of the Carboniferous, that is, the Stephanian, facies is not present in this country, but where strata corresponding to the Stephanian exist, as in northern France, the Carboniferous passes conformably upwards into the Permian. These transition deposits are, therefore, known generally as Permo-Carboniferous, and are present, together with the Permian, in southern Europe, eastern Russia, central Asia, India, Australia, South Africa and South America. In these areas they attain a great extent and thickness.

Deposits in Britain. The Permian strata in Britain are composed of a terrestrial facies, which constitutes the *Lower Permian*, and a marine facies, known as *Upper Permian*. These are both present in the extensive deposits exposed in a long belt which extends from North Shields and the Sunderland area in Durham, through the centre of Yorkshire, to the border districts of Derby and Nottinghamshire. In this area the Upper Permian deposits consist of red marls, beds of salt and intercalated limestone in thin layers, the whole attaining 500 feet in thickness. They overlie a very thick bed of magnesian limestone; this reaches a thickness of 800 feet in Durham, but is much reduced farther south. These rocks are exposed, and fossils may be obtained in many areas, notably the Doncaster, Brodsworth, Cadeby, Pontefract and Tadcaster districts of Yorkshire, the Mansfield and Worksop districts of Nottingham, and at Marsden, Ferryhill, Fulwell in Durham and the coast north of Hartlepool. Below these rocks are the Lower Permian strata, consisting of marl slates beneath which are the yellow sands, the whole of about 150 feet in thickness (*see* map p. 95).

New Red Sandstones. The New Red Sandstones are much in evidence, intercalated with marls and breccias, in the Coventry and Kenilworth areas of Warwickshire, to the west of Birmingham, in the West Bromwich district, and in the northern part of Worcestershire. There are several outcrops in Staffordshire, notably the Clent hills, and in Shropshire, where, in the Enville area, the Permian marls, breccias and conglomerates reach a thickness of 800 feet.

In Lancashire, on the Pennine slopes to the east of Manchester and Stockport, the New Red Sandstone attains a thickness of 1,000 feet, while the marls and limestones reach to another 230 feet. Farther north, and still to the west of the Pennine ridge, the Permian rocks are found in great thickness throughout the Vale of the Eden, reaching almost to Carlisle from Kirkby Stephen in Westmorland. There the New Red Sandstone reaches 1,500 feet in thickness, while above this are thin beds of limestone and red shale. At St. Bee's Head, at Egremont, and farther south in the Clitheroe area and east of Preston are more small outcrops of these strata. The Permian rocks appear in the Isle of Man and, still farther west, in Ireland, at Cultra, near Belfast, and at Armagh and in eastern Tyrone as small patches which have survived denudation. In eastern England the Permian rocks have been found from borings to exist in Lincolnshire, where, composed mainly of magnesian limestone and marl, they were reached at a depth of 1,100 feet below the surface and extended to a further depth of about 600 feet. There are also deposits of Permian rocks, red marls with grey breccias and sandstones, in Leicestershire, which reach a thickness of about 60 feet.

Permian Devon. The Permian deposits are presented in their greatest development in eastern Devon. There the well-known red earth produced by the red marls, soft red sandstones, red conglomerates and breccia—intensified in the districts north of Torquay by the dark red Watcombe clays—are a most distinguishing feature of the products of Permian times. Altogether, these various strata attain a thickness of about 2,000 feet, covering a large area from Paignton northwards, through Torquay, Teignmouth, Dawlish and Exmouth, to Exeter, and thence to Tiverton; a narrow belt extends into Somerset to the Wiveliscombe area. From near Budleigh Salterton, in the east, to Crediton and Hatherleigh, in the west, the county displays the rich red fields, red lanes and combes peculiar to these soft Permian strata.

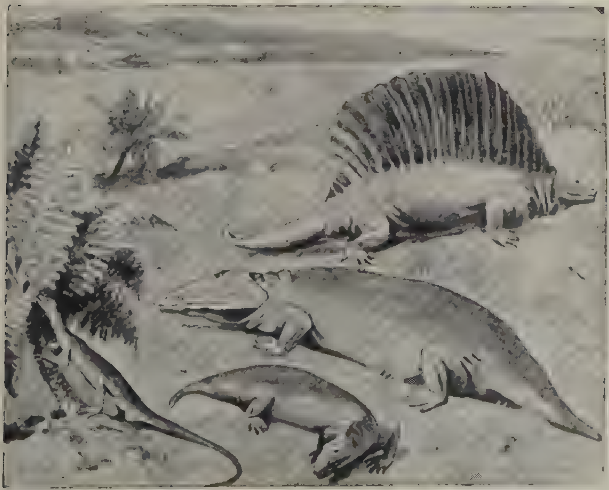
In Scotland there is a small extension of the Cumbrian facies into Annandale, to Dumfries and to the Thornhill area of Nithsdale, where various beds of sandstones, breccias and conglomerates attain a thickness of over 1,000 feet; elsewhere the Permian rocks are not much in evidence, a small tract being near Mauchline in Ayrshire and others in the north, to the east of Elgin and near Cummingstone.

From this superficial survey we see how extensive were the Permian deposits over this country following the low-lying and tropical Carboniferous period. Bearing in mind the terrestrial and wind-formed character of the Lower Permian series, it is assumed that there was a general uplift of the land, a gradual decline of the tropical forests; coal seams are less frequent, and the soft yellow sands, devoid of fossils, came to be deposited over a large area of one-time Carboniferous regions. Thus the various strata of the Lower Permian terrestrial facies indicate that arid conditions gradually replaced the prolific vegetation of what is now southern Britain, the North Sea and Germany. The German extension of the Permian strata is known as ' Dyas.'

Permian Deposits in Europe. The Upper Permian reveals a subsequent submergence of much of the above area, when great beds of limestone were deposited in a sea which ultimately became land-locked, like the present-day Caspian. Desert conditions began to prevail around this shrinking sea. The thick bed of limestone has since become converted into dolomite or magnesian limestone by the magnesium salts dissolved in the saturated waters, which gradually evaporated into salt lakes. Fossils were, therefore, not plentiful, as these evaporating lakes came to resemble the Dead Sea. Eventually, the great beds of rock salt, which are found among the red marls and constitute such a valuable economic deposit in Germany, were formed, together with the extensive beds of anhydrite and gypsum. Then still more arid conditions occurred; the amphibians, which had once flourished on the sandy and muddy shores and left their footprints so plentifully behind them, now gave place to lizard-like reptiles, which roamed among the rank prairie grasses for their numerous insect prey. Thus what had in earlier Permian times been the great Germano-British inland sea had now become the great Germano-British desert, and, with the passing of the life of the period, the Palaeozoic era ended.

Permian Flora and Fauna. The life of the Permian period indicates a great decline in old forms, which for hundreds of millions of years had flourished, and points to the dawn of a new age, the Mesozoic or Middle Life era. For instance, the last of the trilobites occur in the Permian of North America; the last of the *Orthoceratidae* also, and the *Goniatitidae* of the Upper Carboniferous. The flora of this latter period also came to an end in the Permian.

The older types of fishes left few descendants. On the other hand, beyond the desert conditions which had supervened in the Germano-British area, there occurred throughout the world in Permian times a decided transition. The ammonites took the place of the goniatites; great tree-ferns developed, particularly *Caulopteris* and *Callipteris*; conifers became prolific, the yew-like *Walchia* flourishing in the drier conditions, together with the *Ullmannia*. The earliest types of cycads made their appearance in *Pterophyllum* and *Plagiozamites*. The araucarians, *Cordaites* and *Cordioxylon*, were in evidence, together with the remarkable ginkgo (maidenhair tree), which still survives. Thus we find vegetation beginning to approach modern types.



FIRST AGE OF REPTILES. In the Permian Period arid conditions arose, amphibians took to life on dry land and reptilian forms became established and increased. In this reconstruction the creature with the spiny frill rising from its backbone is a ground lizard (Edaphosaurus), 6 ft. long. Beneath it are examples of Cacops and Eryops, while the small lizard-like reptile on the left is a Proterosaurus. Top right, actual fossil of a 'face lizard,' Metoposaurus, a grotesque aquatic rival of the reptiles, which never developed beyond the tadpole stage.

The Permian fauna exhibits this still more strikingly, for while labyrinthodonts flourished in the world-wide waters, together with the ganoid fishes such as, for instance, *Platysomus* and the older molluscs, *Orthoceras*, *Nautilus* and *Cyrtoceras*, many of the reptiles were taking to the land as their permanent home, and the earliest known lizard appeared, the *Proterosaurus*. Thus was the first great advance achieved; the vertebrates began their never-ending war of destruction against the teeming invertebrates, the insect life which threatened to denude the world of vegetation. Other singular reptiles were *Cacops*, *Eryops* and the ground-lizard (*Edaphosaurus*), a creature about six feet in length. The *Cotylosaurus* is another, much resembling present-day species. These terrestrial creatures were all lizard-like in build with straddling legs and powerful head-shields; some returned to the water periodically to lay their eggs and, tadpole-like, spent the earliest part of their existence there, but gradually they appear to have abandoned the water for breeding and adapted themselves to life in the grassy steppes or forests. These species at the close of the long Palaeozoic era (approaching a hundred million years ago) are the direct ancestors of the mammals which were soon to make their appearance, together with bird life, in the ensuing Mesozoic era.

LESSON 13

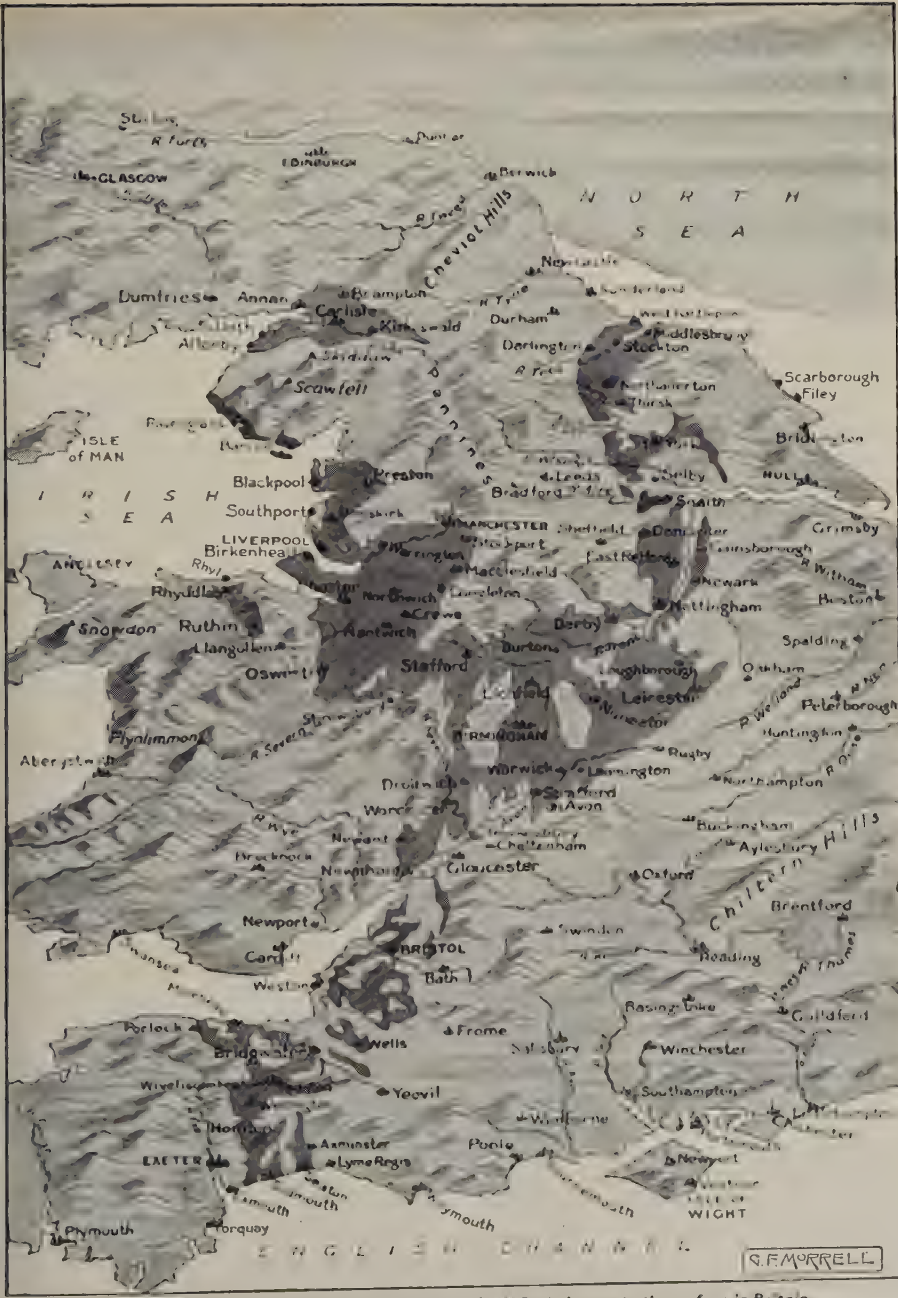
Deserts and Lakes of Triassic England

The Triassic period is the first of the three great comprehensive divisions into which the long Mesozoic era, estimated to extend over 80 to 90 million years, is divided. The Mesozoic (middle-life) was a time of transition from the Palaeozoic or ancient-life era to the Cainozoic or recent-life era, and comprises three periods, the *Triassic*, *Jurassic* and *Cretaceous*. It was essentially the era of reptiles and amphibians, many species attaining enormous dimensions, whereas the Cainozoic, which covers the last 10 to 20 million years, is regarded as the era of mammals. The Mesozoic era is frequently referred to as the Secondary, according to a less satisfactory classification. It must be remembered that, while it is necessary for geological classification to regard these eras and periods as distinct, there were no breaks in geological time, the transition from period to period being gradual and continuous. Each *period*, however, is represented by a *system* of rocks or strata, the system being subdivided into different *series*, each bearing a distinctive name and representing a successive *epoch*.

Bunter and Keuper Rocks. The Triassic system of rocks in Britain is divided into the Bunter and Keuper series. The former attains a thickness of about 2,200 ft., and is composed of lower mottled sandstone, chiefly red, followed by pebble beds overlain by the upper mottled sandstone. Above this series is the more extensive Keuper series, which attains a maximum thickness of about 3,500 feet and is composed of sandstone and breccia at the base—with shales, sandstone, red marls, dolomitic limestones and conglomerate, together with extensive beds of rock salt above. The name ‘ Trias ’ meaning ‘ triple,’ was given by Von Alberti in 1834 owing to a threefold series being present in Germany, but it will be seen that one series is missing in this country. This is the Muschelkalk, a marine deposit between the Bunter and the Keuper series, composed of massive dolomitic limestone attaining a thickness of about 1,000 feet, containing abundant fossils of crinoids and, in particular, bivalve shells (in German ‘muscheln’), from which this series gets its name ‘ Muschelkalk.’ Over the Keuper is a thin transition bed of Rhaetic limestone, which is also generally regarded as Triassic.

In Britain the Triassic beds approach the surface over the whole of Cheshire, over a large area of south and west Lancashire, nearly the whole of Nottinghamshire, and parts of Durham and Yorkshire, from near Hartlepool and Redcar southward almost to Ripon and York. They continue beneath the recent alluvium of the Ouse and Trent valleys to Nottinghamshire, where, throughout the western half of the county, the Bunter series approaches the surface. Nottingham castle is built on a rock of the Bunter pebble beds. Over a large area of the midlands from north Staffordshire, Derbyshire, Leicestershire and Warwickshire to Worcestershire and Gloucestershire, extend the Keuper beds of the upper Trias; but below these are, over much of the area, the Bunter beds of the lower Trias. These latter approach the surface without the superimposed Keuper in west Cheshire, including Chester, and most of the Wirral, north Shropshire—where the Bunter pebble beds are chiefly in evidence—and also in the Manchester and Liverpool areas of south Lancashire. Northwards the Bunter facies extend to Furness and the Cumberland coastal area to St. Bees, where they attain a thickness of about 1,000 feet. Borings in the Isle of Man have also revealed their presence.

The Bunter cover a large area of the Vale of Eden, and although the Keuper series covers them in the Carlisle district, they extend into Scotland to the Dumfries district and form some isolated patches in Dumfriesshire and Ayrshire. An area of the Bunter bright red sandstone in the Isle

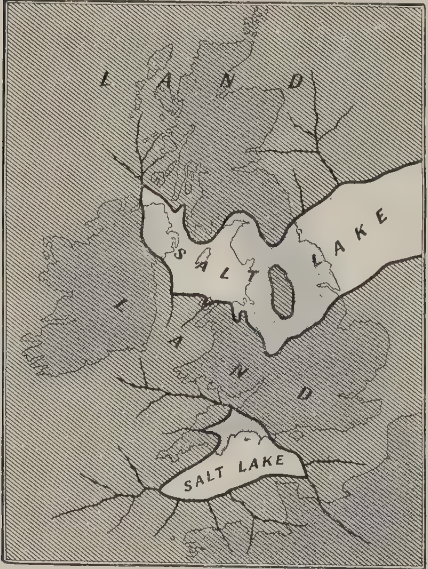


TRIASSIC PERIOD. Regions where the rocks of this Period come to the surface in Britain.

of Arran reaches to about 1,000 feet in thickness; elsewhere it is evident only in Elgin, to the west of Lossiemouth.

Throughout a large area of south-east England the Trias formations are known to extend below the superimposed strata of later deposits, borings having revealed the Keuper beds in Northamptonshire and Kent. In Oxfordshire the Keuper series was found about 600 feet below the surface. Over a large area of Somerset and east Devon the bright red sandstone of the Bunter series may be studied conveniently, particularly along the cliff face between Sidmouth and Budleigh Salterton, where it presents a thickness of nearly 400 feet, resting upon about 80 feet of the Bunter pebble beds. These strata reappear in the Cherbourg area of France.

The red marls and sandstone of the Keuper may be well observed on the cliff-face between Axmouth, Seaton and Sidmouth, where they reach a thickness of nearly 1,400 feet. They are also present as red breccias and sandstones round the Quantock and Malvern hills, along the edge of Bridgwater Bay, east of Minehead, in the Bristol area, and in isolated patches across the Channel between Cardiff and Porthcawl. In Ireland the Keuper is chiefly in the Belfast area, along the shores of the lough and in the valley of the Lagan, where Bunter is also observed. The two are also well presented in the Red Bay area of Cushendall and on the east side of Lough Foyle, while small patches occur in Tyrone and Londonderry.



TRIASSIC BRITAIN. At the commencement of the Triassic period a large part of Britain was composed of desert. Then the land sank and two great salt lakes came into existence, which in turn gave place to desert conditions once more.

Formation of Salt Lakes. At the beginning of Triassic times the districts mentioned above were mainly desert, resembling large areas of present-day central Asia; this is evidenced by the lower red and mottled sandstones of the Bunter series, which are obviously wind-blown desert sand. These desert conditions were a continuation of those of the Permian, but in course of time two saline lakes were formed (*see* accompanying map). The northern lake was far the larger and more saline; the southern lake covered much of the area of the previous Permian lake. They were fed by rivers which brought down large quantities of rolled pebbles, red sand and detritus, which deposited on the shores and lake beds material that went to form the Bunter pebble beds. The lakes subsequently shrank and vanished during the millions of years of Bunter times; then the Bunter bright red and mottled sands of the desert covered the pebble beds of the lakes and eventually became hardened into sandstone.

Germano-British Gulf. Later on, the Keuper epoch began with a general submergence, the sea from the south invading for a time a large portion of the low-lying desert and forming a great land-locked gulf, known to us as the Germano-British gulf. This gulf covered most of Germany, and resulted in the deposition of thick beds of limestone, known as the Muschelkalk, extending over Heligoland into the North Sea. The British area, however, was too elevated for the Muschelkalk series to form. Instead, shallows—represented by white sands, various coloured clays and pebbles—marked a shore line which gradually separated a large inland sea from the gulf. This covered the whole of the midlands, what is now the Irish Sea, northern Ireland and the low-lying areas of the west of Scotland; a narrow channel extended southwards across Devon to northern France. The secular rise and fall of the land through the millions of years of the Keuper times produced the distinctive strata of this series and the varying shore-line of this inland sea. A constant accretion of salt dissolved from the rocks and, permeating the growing bed of marl at the bottom, gradually reduced the sea to an intensely salt lake, in which thick beds of salt were deposited. Thus the thickest beds of the Keuper series of red marls were formed, attaining in Cheshire a thickness of 3,000 feet, with beds of rock-salt as much as 100 feet thick; these also occur in north Yorkshire and Worcestershire, the salt deposits constituting a most valuable commercial product of this ancient Triassic salt-lake. In later Keuper times the lake expanded as the result of a general submergence of the land, and a great land-locked sea took its place. At this time, then, sea covered Germany, the Vosges and also Tirol—regions which constituted a wide strait to the great ocean stretching to the south-east. The Alps and Vosges had not at that period come into existence.

Triassic Flora and Fauna. The Triassic flora in the deposits of the salt-basins and desert areas is, of course, scarce, but elsewhere, on mountain slopes, the banks of rivers and in marshy regions, there existed sufficient flora to produce beds of shale and coal-seams containing fossil forms; while plants, tree stems and seeds were often brought down by floods becoming fossilized in the lacustrine sediments. Conifers, resembling the cypress, were most abundant, together with *Albertia*, *Schizolepis* and *Baiera*. The cycads *Pterophyllum, Zamites*, *Podozamites* and *Otozamites* flourished; while the equisetums or horse-tail reeds were plentiful along river banks and marshy tracts. Some ferns flourished, such as *Anomopteris*, *Chelipteris*, *Lacopteris* and *Coniopteris*.

The Triassic fauna is of particular interest. The fishes, *Acrodus*, *Hybodus*, *Palaeoniscus*, *Gyrolepis*, *Pholidophorus*, and the ancient *Ceratodus* flourished. Cephalopods were plentiful in the Muschelkalk of Germany, including *Nautilus* and the Palaeozoic *Orthoceras*, together with the ammonite *Ceratites*; but many new genera and species of ammonites appear in this period, as *Phylloceras*, *Pinacoceras* and *Trachyceras*. The crinoid *Encrinus liliiformis* was most prolific, together with numerous genera of Lamellibranchs, particularly *Corbula*, *Myophoria*, and *Pecten*. Also the brachiopods *Rhynchonella* and *Terebratula*.

New Reptiles. It is among the Reptilia that the most surprising development occurred. Numerous types of giant lizards with mouths resembling those of turtles had now evolved. Some were tusked, like the *Dicynodon*; the *Hyperodapedon* and *Telerpeton* were found in the Keuper series, together with bones and teeth of labyrinthodons, whose footprints are also plentiful, both in the Keuper and Bunter deposits—indicating that they inhabited the shores of the lakes. The *Mastodonsaurus* and *Trematosaurus* also inhabited the sandy lake-shores of the Bunter epoch, but the millions of years which intervened between this and the later Keuper times saw an enormous development from these early types. The first true crocodiles appear. Strange creatures exhibiting close affinities to both amphibians and land reptiles were the Theriodonts, two of which are shown in this page; from these creatures mammals may have descended. Plesiosaurs, reptiles which took to an entirely aquatic life and developed fin-like paddles instead of legs, made their first appearance in late Triassic times.

FAUNA OF THE TRIASSIC. Evolution now took place towards mammalian forms which made their appearance towards the end of the Period. The large creatures seen here are Cynognathus (above) and Kannemeyeria (below). Both are representatives of the Theriodontia reptiles that closely resembled both amphibians and mammals and from which mammals have descended.

The First Mammal. Most important of all animal development was the appearance of the first mammal. This was a small marsupial type of creature, the *Microlestes*, which is believed to have resembled the *Ornithorhynchus* of Australia. But the age of great dinosaurs was at hand. The *Palaeosaurus*, *Teratosaurus* and *Thecodontosaurus* had already appeared, and at least 70,000,000 years were to pass before mammals were to dominate the world.

LESSON 14

Strata and Fauna of the Lias

The Jurassic period is named after the Jura mountains between France and Switzerland, where its typical rocks are exceptionally developed. The entire series are well represented in England, where they are divided into Lower Jurassic or Lias and Middle Jurassic, which with Upper Jurassic, constitute Oolite. These are further subdivided, according to the type of strata together with the successive epochs indicated by the species of fossils; the Lias being divided into Upper, Middle and Lower Lias, while the Oolite is divided into Upper, Middle and Lower Oolite, containing between them seven sections. These are discussed in our next Lesson.

The name Lias was originally given by quarrymen to the hard limestones which were at the base of this series; subsequently it became applied to the whole facies. These consist of the following beds: *Upper Lias*, clays intercalated with thin beds of limestone; *Middle Lias*, beds of sandy clays, shales, and marlstone; and *Lower Lias*, white and blue limestones alternating with shales and clays.

Lower Lias. The Lower Lias strata rest conformably upon the Rhaetic transition beds overlying the Trias. They are well displayed along the cliffs of the Dorset coast from Lyme Regis to Bridport, attaining a thickness of about 500 feet. They stretch across the width of England in a belt, as far as the Yorkshire coast; extending beneath Somerset, appearing at Watchet and in quarries near Ilminster; pass round the Mendip Hills and across the Bristol Channel, where they are well exposed in the cliffs between Penarth and Dunraven Castle. The Lower Lias beds have been found by borings in Gloucestershire, Oxon, and Warwickshire, to be about 450 feet thick; passing beneath east Leicestershire they attain a thickness of 700 feet in Lincolnshire, and through central Yorkshire to the coast between Redcar and Whitby, where they attain a thickness of over 700 feet. Lower Lias deposits are present to the west of Carlisle and over a few isolated patches along the coast of Antrim. In Scotland they are found in a few areas of Argyll, in Mull, and as far north as Raasay and Broadford in Skye; while in Sutherland they occur beneath Dunrobin castle. These are but remnants that have survived denudation, their presence indicating roughly the extent of this northern inlet of the Liassic Sea.

Middle Lias. The Middle Lias beds consist chiefly of blue micaceous clays resting upon sandy clays and overlain by yellow sands, clays and a bed of ferruginous limestone which varies in thickness from about a foot in southern England to 150 feet in the Cleveland district of Yorkshire (where it is of great economic value) and also in the Midlands. The beds of the Middle Lias attain a thickness of about 350 feet in Dorset and may be seen to advantage in the cliffs between Charmouth and Bridport. Like the Lower Lias, these beds extend beneath Somerset, Gloucestershire and other areas, appearing more particularly at Glastonbury, Yeovil, Banbury, and the famous escarpment of Edge Hill. In these areas the valuable ferruginous limestone reaches about 25 feet in thickness. In south Lincolnshire, in the Grantham area, the Middle Lias attains considerable thickness; and then after thinning out beneath the Humber and Derwent area it thickens into the valuable outcrop of north Yorkshire. There the ferruginous deposit of 'marlstone' or ironstone reaches a thickness of 150 feet and its proximity to the thick seams of coal in the adjoining districts has been a great source of wealth to this county. Only a small residue of the Middle Lias is found farther north—in the Inner Hebrides at Scarpa, Raasay, and Mull.

Upper Lias. The Upper Lias also extends from Dorset to the Yorkshire coast, where it may be easily studied at Whitby in particular. The beds are best developed, however, in Northamptonshire where, composed mainly of dark clay, they are nearly 160 feet thick, and in Yorkshire where, chiefly composed of blue shales and alum shales with overlying sands, they reach to 330 feet in thickness. They are also present in small areas above the Middle Lias in the Hebrides, attaining a maximum thickness of about 80 feet; and are in evidence more particularly at Northampton, Lincoln, Yeovil, and Ilminster, chiefly in quarries and cuttings where numerous fossils are present.

Secular Rise and Fall. These Liassic deposits indicate that an extensive sea with low sandy shores, river estuaries and deltas,

mud flats and the like, took the place of the arid salt-lake area of Triassic times. This was part of the process known as the secular rise and fall of large land areas relative to the sea level, which we see continuing through the long aeons of geological time down to the present age. This doctrine of secular movements of land (i.e. through vastly extended periods without observed recurrence in the form of a cycle or period) has been held by geologists for over a century.

The lithosphere or rocky crust of the earth is relatively very thin, and continues to be subject to this 'bulging here and sinking there' over large areas. Ages ago the lithosphere was thinner, and such movements were doubtless more pronounced.

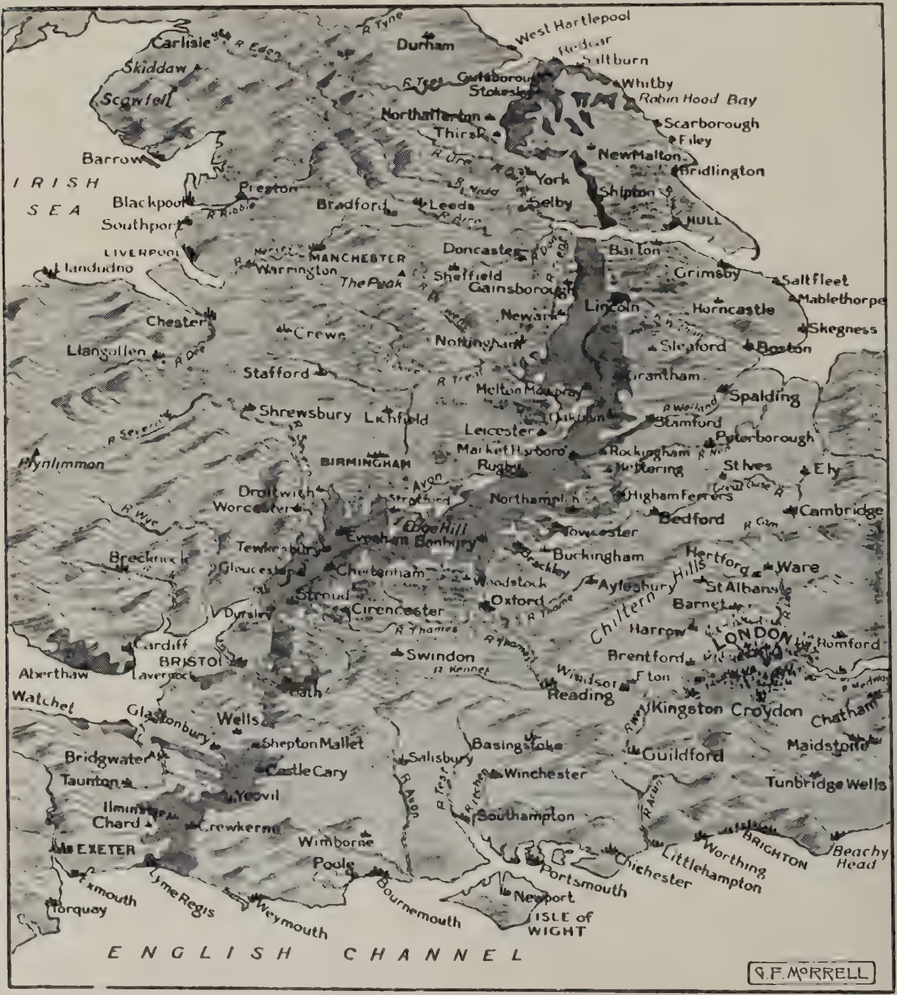
Jurassic Rocks. The rocks of the Jurassic period are evidence of such a subsidence wherever they occur. Thus throughout central, southern and the greater part of western Europe a general subsidence took place; Jurassic deposits of great thickness cover large areas both at and below the surface, the Lias series alone reaching to a thickness of over 2,000 feet in south-eastern France. On the other hand, eastern Europe and the north Baltic regions were raised; and these, together with the mountainous areas of Britain and Scandinavia, were dry land largely covered with a rich vegetation and prolific fauna, to judge by the fossils which were preserved. Though, then, the Jurassic deposits generally represent areas that were submerged, they also incidentally contain relics of the land areas where, as a rule, no deposit was made and of which we would otherwise have no record.

Evidence of this tilting of the land is very strikingly shown in the United States of America. During Jurassic times, when the western districts sank gradually below the Jurassic sea and so came to be covered by a thick deposit of sediment and remains of marine organisms, about 6,000

LIASSIC FORMATIONS IN BRITAIN. Upper photo, a quarry in the Lower Lias limestone at Bridgend, Glamorgan; middle, an isolated block of Middle Lias sandstone on a pillar of shale, on the foreshore at Sheepstone, Yorks: bottom, Upper Lias cliffs at Saltwick bay, Yorks.

Courtesy of the Geological Survey and Museum feet in thickness, the districts east of the Rockies went through a period of uplift which lasted throughout Jurassic times, and consequently we find there no appreciable deposits of this vast period—a period which may have lasted 20,000,000 years.

In Britain, the Liassic probably covered a third or possibly nearly half of the Jurassic period, the submergence that at length converted the Keuper depression into an arm of the sea being very slow. This inlet was not unlike the present Bay of Fundy and extended over the Inner Hebrides, the Firth of Clyde and most of Ulster. Central, northern, and southern England, except the Cornish area and the Thames valley, were beneath the sea and sinking deeper and deeper. The Pennines, the Downs, the Chilterns, the Purbeck hills did not exist; neither did the volcanic areas of Antrim, Mull, or Skye. The strata of the Liassic series, the clays, sand, and marls, are



JURASSIC AGE. Perspective map showing where the Jurassic strata come to the surface in Britain.

evidence of the gradual encroachment of the sea over this part of the world.

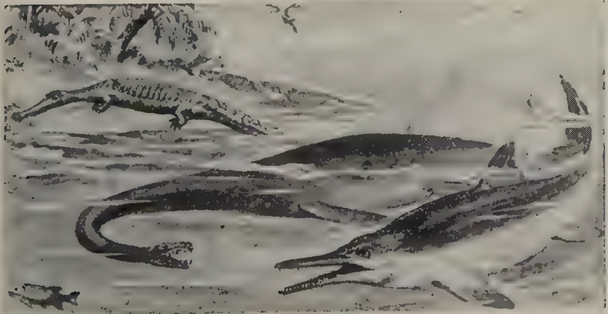
Liassic Fossil Remains. The life of the Liassic age has, therefore, been abundantly preserved in fossilized form under very favourable conditions, and is found to be totally different from much that existed at the close of the Palaeozoic era. The flora consisted largely of palm-like cycads, which were so prolific that the period is known botanically as the Age of Cycads. Equisetums were still plentiful, *Equisetum arenaceum* attaining an immense size. The ferns *Sphenopteris*, *Lacopteris* and many others flourished from Triassic times, as did the ginkgo or maidenhair tree family. Conifers were abundant.

The fauna of these times was varied, prolific and very remarkable. The ammonites had developed into numerous very distinctive species characteristic of a particular zone of the Liassic deposits: the Lower Liassic characterized by *planorbis*, *bucklandi*, *oxynotus*, *jamesoni* and *capricornus*; the Middle Liassic by *margaritatus* and *spinatus*; the Upper Liassic by *serpentinus*, *communis* and *jurensis*.

Palaeozoic fishes had almost died out, their place being taken by numerous species of which *Dapedius*, *Acrodus* and *Hybodus* are in the Lower Lias; *Lepidotus* and *Leptolepis* in the Upper. The belemnites had become remarkably abundant, together with the lamellibranchs and gastropods. The brachiopods *Cadomella* and *Spiriferina* were characteristic of the Lias, while *Rhynconella tetrahedra* and *Terebratula punctata* were prolific.

Insect life was also abundant, and there appeared the earliest flies, *Diptera*, together with the earliest known ants, *Hymenoptera*.

Reptilia made the greatest advance, for while the labyrinthodonts and anomodonts of earlier ages had disappeared, the first of the dinosaurs, such as the *Palaeosaurus*



AGE OF GIANT REPTILES. In the Jurassic Period reptiles became masters of every element. In the reconstruction above, the fish-like reptile on the right is an ichthyosaurus, and top right is shown the gigantic fossil of one of these creatures, brought to light in 1928 in a quarry at Harbury (see p. 65). The reptile with a long swan-like neck is a plesiosaurus (see fossil, p. 66), and crawling on to the bank is an early type of crocodile, the steneosaurus. Bottom right, ammonites of the Liassic Period.

and also the *Steneosaurus*, a carnivorous crocodile 18 feet long, had evolved. Most remarkable were the great fish-lizards, the *Ichthyosaurus* and *Plesiosaurus*. The ichthyosaurs existed in great numbers in the shallow Liassic seas and attained a length of as much as 30 feet; their bodies resembled whales except that the tail fins were upright, like those of fishes. They had acquired the mammalian function of bringing forth their young alive. The plesiosaurs were also great sea-reptiles, possessed of a long neck and small head with numerous teeth (*see* p. 66). They attained a length of about 14 feet and had paddles like the ichthyosaurs.

LESSON 15

Characteristics of the Oolite

The geological formations known collectively as Oolite (Gr. *oon*, egg; *lithos*, stone; the grains of calcite in the limestone characteristic of the formation resemble hard roe) represent the second and largest series of rocks of the Jurassic period and comprise the Middle and Upper Jurassic subdivisions.

The Oolite is divided into the following series:

Upper	Purbeckian.	
	Portlandian.	
	Kimmeridgian.	
Middle	Corallian and Ampthill Clays.	
	Oxfordian	Oxford Clay. Callovian.
Lower	Bathonian or Great Oolite.	
	Bajocian or Inferior Oolite.	

These series extend as an escarpment north and north-eastwards from Dorset to Yorkshire. Each division has, however, to be considered separately here, since the beds possess so much local differentiation, being largely composed of various clays intercalated with beds of limestone, sands and sandstone.

Lower Oolite Series. The Lower Oolite deposits extend from Dorset and Wiltshire, through Oxfordshire, Northamptonshire and Lincolnshire, to the north of Yorkshire. In the south-west they consist chiefly of limestones overlying sands, indicating that a shallow sea covered this area, but clays deposited farther north bespeak estuarine conditions.

The Inferior Oolite is also known as Bajocian, from Bayeux in France, where it is well developed. It includes the subdivision Aalenian. In England it is well presented from Bridport to Burton Bradstock, and around the Yeovil, Bath, Sherborne, Dundry and Cotswold hills areas. Though the limestone beds are thin in the Dorset and Wiltshire areas, being between 10 and 21 feet thick, the beds, with freestones and ragstones, attain a thickness of between 100 and 250 feet in the Bath area and east of the Cotswolds. From the Oxfordshire area to Northamptonshire, the Inferior Oolite is composed chiefly of sands and ironstone, reaching in places to about 60 feet thick. In Lincolnshire, the limestones form the famous cliff escarpment as much as 150 feet thick. It is sandy in places and extends to the alternating limestone and estuarine sandstones and shales of north Yorkshire, which attain a thickness of about 400 feet and may be seen well exposed in the Robin Hood's Bay district and the Blea Wyke area. Elsewhere, this formation is only present in Skye, Raasay, Eigg, Muck, and a few small patches, including the Great Oolite, on the coast of Sutherland and Elgin. Its thickness reaches 300 feet in the Jura area and nearly 1,000 feet in Provence.

Great Oolite Series. The Great Oolite or Bathonian (named from Bath, where it is well exposed) extends from Dorset to Yorkshire, adjoining and covering much of the Inferior Oolite. Its various strata attain a thickness of about 250 feet in Dorset and the Bath area, dwindling to about 140 feet in Oxfordshire and 100 feet in Lincolnshire, The Great Oolite is very fossiliferous, and may be studied to advantage at Bath, Minchinhampton, Stonesfield, Northampton, Bedford, Lincoln and Gristhorpe Bay on the Yorkshire coast.

The Great Oolite includes the Cornbrash, Forest Marble, Stonesfield Slate and Fuller's Earth formations.

The *Cornbrash* consists of a very friable earthy limestone which covers the Great Oolite to a depth of between 5 and 40 feet over its entire area from near Weymouth to the Yorkshire coast. It is conducive to the raising of fine corn crops owing to its friable or *brashy* texture.

The *Forest Marble* derives its name from Wychwood forest, where it is extensively quarried. It is nearly a hundred feet thick in Dorset and extends from there to the above area and into Buckinghamshire, where it thins out and the white marly limestone, the so-called 'marble,' gives place to a thin belt of clay. Thus there is evidence that the shallow sea here became an estuary or delta.

The *Fuller's Earth* or Fullonian formation is below the Forest Marble, and extends from Dorset to Bath, Stroud and Cheltenham, attaining a thickness of from 7 to 150 feet. It does not extend farther north than Oxfordshire. Fuller's Earth consists of marly clays with bands of soft limestone; the more refined varieties of the earth, chiefly found in the Bath area, have a considerable commercial value, particularly for fulling cloth.

The *Stonesfield Slate* formation, which is at the base of the Great Oolite series, chiefly in Gloucestershire and Oxfordshire, is named from Stonesfield, where it has long been quarried. It consists of thin flaggy beds of sandy limestones, shales and laminated micaceous sandstones, attaining a thickness of about 30 feet in Oxfordshire. These beds are remarkable for the great number of fossils they contain, among them remains of the marsupial mammals *Phascolotherium* and *Stereognathus*, land plants and insects in profusion, and the reptiles *Plesiosaurus*, *Cetiosaurus*, *Megalosaurus*, and *Teleosaurus*. The fishes *Hybodus*, *Ganodus* and *Ceratodus* are also prolific, and there is evidence of the first bird, *Archaeopteryx*.

ARCHAEOPTERYX. Possessed of teeth as well as beak, with fingers as well as feathers on its wings, the archaeopteryx (Gr. ancient wing), of which a fossilized specimen is illustrated above, was a link between modern birds and primitive reptiles.

Berlin Museum

The *Great* or *Bath Oolite* itself is a bed of limestone reaching to 100 feet thick between Bath and Minchinhampton, and extending from this area to Bradford-on-Avon, Northampton, Bedford, and Lincolnshire, where it gradually thins out. It constitutes the famous freestone known as Bath-stone, and is much quarried in these areas. This deposit is rich in fossils similar to those found in the Stonesfield Slate.

Middle Oolite Series. The Middle Oolite is divided into Oxfordian below and Corallian above, the Oxfordian presenting two formations, the lower being the Callovian and the upper the Oxford Clay.

The *Callovian* or Kellaways Rock named from the village of Kellaways in Wiltshire, varies in thickness from a few feet to 80 feet, and extends from Dorset to Yorkshire, reappearing in Skye. It consists of the calcareous sandstone from which it gets its name. It is rich in fossils, over 200 species of fish being found in it, together with numerous *Ammonites calloviensis*, *Ammonites modiolaris* and belemnites. This formation is well exposed at Weymouth, places in Wiltshire and Oxfordshire, St. Neots, Hackness in Yorkshire, and Uig in Skye.

The *Oxford Clay* above the Callovian consists of stiff blue and brown clays with septarian nodules and bituminous shales. They vary in thickness from 170 to 600 feet, extending from Dorset to Scarborough. This formation indicates a muddy deposit, estuarine probably, in which Lamellibranchs, *Ammonites Jason* and belemnites were abundant, judging by their fossil remains. Plesiosaurs, ichthyosaurs, megalosaurs, crustaceans and insects also flourished.

The *Corallian* indicates the changed conditions of the succeeding age. This formation lies above the Oxford Clay, and is so named because of the masses of reef-building coral existing in its shelly limestone beds, which indicate that it was part of a vast coral reef and that clear tropical seas existed where it is found. This is in Dorset, where it reaches a thickness of about 200 feet, extending northwards through Wiltshire and Oxfordshire. There are also valuable beds of ironstone in Wiltshire. In Buckinghamshire, Bedfordshire, Huntingdonshire and Lincolnshire, the coral limestone is replaced by the Ampthill Clay beds, which are evidence of the river delta or estuary

which had persisted through these Middle Jurassic times.

A prolific fauna flourished. In the limestone, in addition to the coral, sea-urchins and the very abundant *Ammonites perarmatus* and *Ammonites plicatilis*, were the reptilia mentioned above. The rocks with the numerous fossils are well exposed in the cliffs south of Weymouth, at Steeple Ashton, Calne, the Abingdon area, Oxford, Upware in Cambridgeshire, and at Filey, Malton, Scarborough, and the Vale of Pickering, where the beds attain a thickness of 400 feet. They also appear at Clyne Hill in Sutherland.

PORTLANDIAN OOLITE. *Portland stone, named after the Isle of Portland, in Dorset, where it is extensively quarried for building purposes, belongs to the Upper Oolite series. The upper photo is of fossil shells embedded in the stone, revealed by quarrying at Easton, Portland; below is a view of the Portland stone cliffs—Tilly Whim, and Durlston Head—near Swanage, Dorset.*

Geological Survey and Museum

Upper Oolite Series. The lowest of the Upper Oolite series is the Kimmeridgian, which consists of dark grey, shaly clays with occasionally septarian nodules and bands of limestone. They attain a thickness of 1,000 feet at Kimmeridge Bay in Dorset where they are well exposed; this dwindles to about 300 feet in Wiltshire and to less than 100 in Berkshire, Oxfordshire and Buckinghamshire. After passing through Cambridgeshire, they thicken in Lincolnshire to 600 feet. In Yorkshire, the series is not much exposed, except at Speeton Gap, on the coast, and the Vale of Pickering.

The strata indicate a muddy and shallow sea or estuary, in which Lamellibranchs and Cephalopods were numerous, and corals and echinoderms rare; while the ichthyosaurus flourished in the sea, two species of pterosaurs or pterodactyls in the air, and plesiosaurs, pliosaurs, cetiosaurs, megalosaurs, the gigantosaurus and iguanodon roamed the wide low-lying areas, shallow waters, and marshy stretches which covered so much of south-east England in those days of at least 50 million years ago.

Portland and Purbeck Formations. The Portlandian formation, named after the Isle of Portland, where it is well developed, followed as a consequence of another subsidence of the land. Thick beds of limestone and calcareous freestone were laid down in the course of many thousands of years, until layers approaching 300 feet thick were formed. These are well seen in the cliffs from Durlston Head to St. Alban's Head in Dorset; other facies appear at Upwey near Weymouth, at Tisbury in the Vale of Wardour, and at Swindon, where the formation has dwindled to about 100 feet thick. It extends to Oxford, Thame and Aylesbury, but does not appear farther north than Buckinghamshire, though the beds extend a long way south, and reappear in France at Boulogne. The enormous *Ammonites* *giganteus*, like a cart-wheel, flourished then, and the coral *Isastraea oblonga*, together with the tropical marine fauna of late Jurassic times already mentioned. This Portland stone is of considerable commercial value for building.

The Purbeckian formation, named from the Isle of Purbeck, occupies most of this area and is well exposed. It overlies the Portlandian with freshwater limestones followed by layers of ancient earth—the so-called ' dirt-beds '—in which the fossilized stems and roots of Jurassic cycads and conifers have been found *in situ*. These beds are overlain by a marine deposit in which oyster and other fossil shells figure largely, such as may be seen exposed at Durlston Bay near Swanage, where the strata are 400 feet thick. It diminishes westward to Worbarrow Bay and Lulworth Cove, where it is under 200 feet thick. The Purbeckian appears also near Swindon, in the Vale of Wardour, and at various localities and cuttings in Oxfordshire and Bucks, notably at Thame and Aylesbury. The beds come near the surface in parts of Sussex and Kent, while actually protruding near Battle.

The fossil fauna of this formation is largely fresh-water and estuarine, in which crocodiles and turtles figure with numerous fishes and the marsupials *Spalacotherium*, *Plagiaulax* and *Triconodon*. Insects were also prolific among the cycads and conifers. But this last marine deposit indicates the beginning of the great subsidence of the land that heralded the following Cretaceous period. The well-known Purbeck marble, composed mainly of masses of shells of *Paludina* and found at Swanage, marks the end of the long Jurassic period.

LESSON 16

Survey of the Cretaceous Period

The Cretaceous is the third and last period of the Mesozoic Era; it is named from *creta*, Latin for chalk, the formation which is the most extensive of the Cretaceous series. The lower beds are largely of sand and estuarine origin and therefore of a terrestrial character, composed of clays intercalated with layers of sand, particularly in the series present in western Europe. The great mass of the Cretaceous deposits, however, are of marine deposition, oceanic in character and world-wide in extent. They are chiefly composed of great beds of soft limestone in the form of chalk, and comprise one of the most extensive and massive of all the sedimentary strata now existing.

Cretaceous Areas. The Cretaceous facies, as presented in western Europe, extend from Britain (Upper Cretaceous) to northern France, Belgium, north Germany and the south Baltic area, Bohemia and Saxony. This area in Cretaceous times constituted a largely land-locked sea, into which were poured the waters from large rivers from a vast continent to the north. This Cretaceous sea was separated from a great world-wide ocean to the south by an ancient mountainous ridge stretching from what is now Brittany, through the Auvergne and south Germany, to Bohemia. There were then no Pyrenees, Alps or Apennines, nor any English Downs.

South of this ancient ridge exists the world-wide oceanic deposit, the main Cretaceous beds, extending from Portugal across southern Europe to the Carpathians and south Russia to south-west Asia, including the whole of the Mediterranean area and north Africa, and then extending eastward across Arabia to India, Tibet, south China and Japan. All this area was part of the great Cretaceous ocean that covered the equatorial regions and divided the large land areas of the northern continent from those of the southern. All except the north-eastern portion of the North American continent was under a vast Cretaceous bed, which in the west reached 13,000 feet in thickness.

The great equatorial ocean was the cause of the remarkable diversity which began in Cretaceous times between the fauna and flora of the northern continent and the southern. Later on, in the Tertiary Era, this became more marked, and it persists to this day in Australia, the last remnant of the great southern continent of Cretaceous times. South Africa and South America became united to the northern land-mass in later Tertiary times, but not Australasia, the sole representative of the great Gondwana Land (*see* map p. 126) of the Mesozoic Era.

Lower Cretaceous Beds in England. The Lower Cretaceous series are represented in England by the Hastings beds, which consist of Ashdown Sand, the lowest; Wadhurst Clay above; and Tunbridge Wells Sand at the top. Above these is the Weald Clay—the whole attaining in south-east England a thickness of nearly 2,000 feet.

The *Hastings beds* have a total thickness of about 1,000 feet. The Ashdown Sands reach to 400 feet in Ashdown Forest, and compose Crowborough Beacon; they thin out into clays near Hastings. The Wadhurst beds consist of shales and hard clays, and vary between 150 and 160 feet in thickness between Hastings and Wadhurst. They provided much iron ore from medieval times down to the last century, when the last iron-furnace was extinguished at Ashburnham. The Tunbridge Wells Sands consist of calcareous grit, sandstones, shales, clays and sands, the whole attaining a thickness of nearly 400 feet, but thinning out eastward. All the series just mentioned are well shown in the cliff-face between Hastings and Fairlight.

The *Weald Clay* consists of blue and brown clays intercalated with beds of shelly limestone, calcareous sandstone and sands, the whole reaching to a thickness of about 900 feet. These are well shown along the cliffs of the Isle of Wight, extending along the back of the island from the Atherfield rocks south of Brixton, along Brixton Bay, to Brook. The Weald Clay also extends from Hythe to the Vale of Wardour in the west, but is only exposed in the hollow between the North and South Downs and in some small areas, particularly in the Isle of Wight. Farther west, it appears in a great mass at Swanage, where its beds reach a total thickness of over 2,000 feet. From there it crosses the Isle of Purbeck to Worbarrow Bay, where the beds are about 1,200 feet thick. The Wealden formation rapidly thins out northward and westward, being little more than 50 feet thick in the Vale of Wardour, where it is last seen.

The deposits of the Wealden series indicate that a great freshwater basin, known to geologists as the Wealden Lake, covered the southern counties from Dorset to Kent, and also the Channel area to Dieppe and south-eastward to Paris. Early in Cretaceous times the sea penetrated from the south-east, and deposited a great bed of chalk over the whole of the Wealden beds.

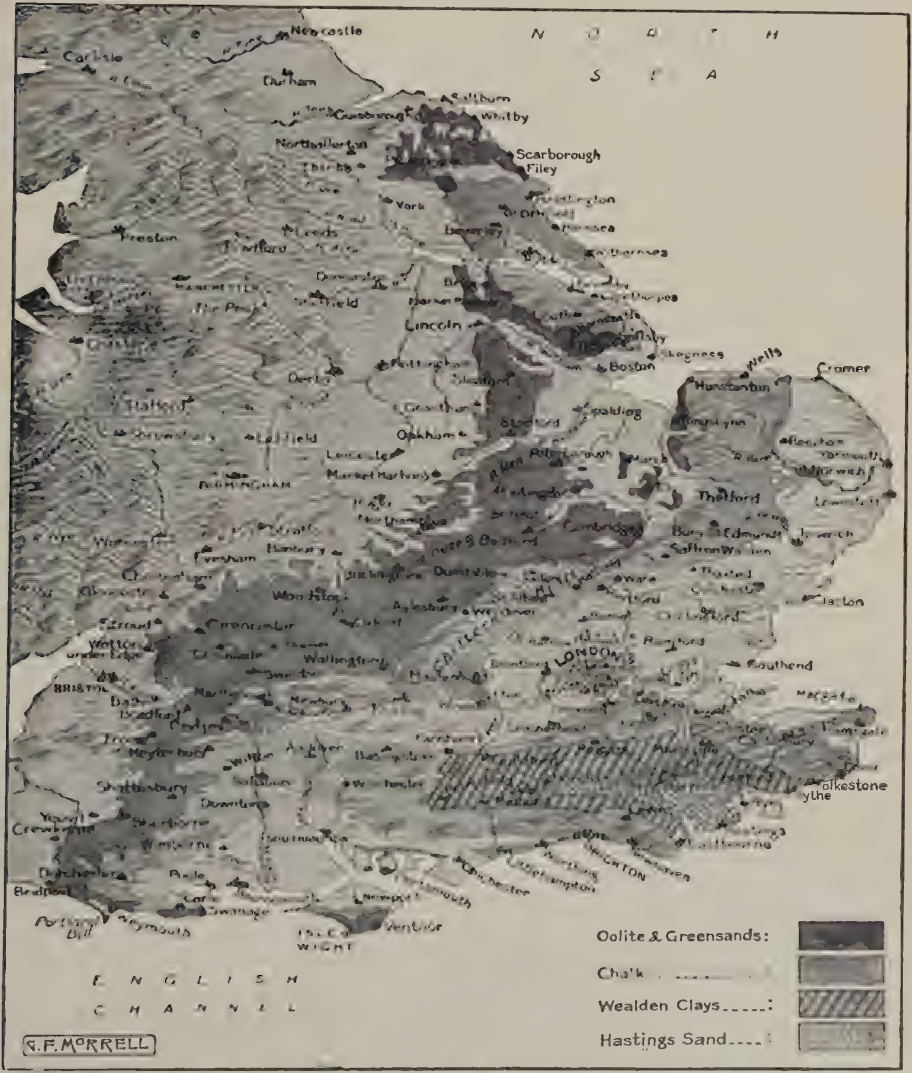
The *Lower Greensand* formation is evidence of the coming of this sea—the sands and thin layers of limestone following the muddy deltaic and freshwater deposits of the Wealden series. The Lower Greensand, or Vectian, as it is sometimes called, from the Isle of Wight (Lat. *Vectis*), where it is well exposed, is represented, in succession upwards, by the Atherfield, Hythe, Sandgate and Folkestone beds. They consist of green, yellow and grey sands, together with layers of clay, limestone and ironstone—the whole attaining a thickness of about 500 feet in Surrey, 250 feet near Sandgate, and thinning out in other directions. The Hythe beds contain layers of hard limestone known as 'ragstone,' which is valuable for building purposes. These deposits were laid down during the gradual submergence of the land which began late in Lower Cretaceous times; and so beds of alternating sands, clays and limestones bear witness to a succession of vacillations ere the great transgression of the sea gave the area an oceanic character.

Northern Marine Beds. In north-east England marine conditions prevailed during Lower Cretaceous times; hence a very different facies is presented in the contemporaneous beds revealed in Norfolk, Lincolnshire and the East Riding of Yorkshire. These are evidence of the existence of a narrow arm of the sea extending over the greater part of the present North Sea and linked up with the sea which then covered north and east Russia by way of Spitsbergen —in those days more tropical than arctic. Fossils, particularly ammonites, found in this district of England are singularly like those found in the Russian area just mentioned, whereas they are totally dissimilar to those ammonites and molluscs found in the contemporaneous beds of southern England. An elevated ridge which appears to have extended from the Charnwood Forest area of Leicestershire to the Ardennes, and part of which is now far beneath London, is believed to have separated these two areas.

The deposits of this northern marine series of beds consist of dark clays and shales, the chief of which is the Speeton Clay, well exposed at Speeton Gap, south of Filey, in Yorkshire. These beds are exposed from Caistor to Tealby, to Spilsby, Candlesby and Willoughby at the south of the Lincoln Wolds, attaining in places a thickness of nearly 100 feet. Thence they extend south to the Hunstanton and Downham Market area of Norfolk, and reappear in a few isolated areas farther south, e.g. at Biggleswade.

Fossils of the Period. Fossils are prolific of both flora and fauna in favoured situations, the former in Lower Cretaceous times being very similar to the Jurassic forms. They were of a type that denoted a warm climate even in Greenland and Spitsbergen. Conifers and cycads, together with the ferns *Alethopteris* and *Sphenopteris*, predominated, but plants which were the ancestors of our flowering trees and shrubs had appeared.

While the reptilian ichthyosaurs and plesiosaurs were declining in numbers, the great dinosaurs increased enormously, attaining a great variety of species—more particularly the Trachodon (*see* reconstruction in page 118), the *Cetiosaurus brevis*, *Megalosaurus Bucklandi*, the sea serpent *Mosasaurus* and the famous Iguanodon. Numerous remains of *Iguanodon Mantelli* have been found in the Tilgate beds in Sussex, and numbers of complete skeletons in Belgium. Large numbers of ammonites and cephalopods flourished in the sea, together with fishes—in particular, the *Hybodus* and *Lepidotus Fittoni*; while the



CRETACEOUS AGE. Map showing the various types of strata which constitute the Cretaceous Period in England. They continue under the Channel into northern France, Belgium and beyond.

TRACHODON DINOSAURUS. *This uncouth animal lived in Cretaceous times. It was herbivorous, and walked on two feet, using the forefeet to support the body when feeding. It was some 34 feet long and is noteworthy for the prolongation of the jaws, giving it the appearance of a duck-billed platypus.*

Lepidotus Mantelli frequented the great Wealden Lake.

The Isle of Wight Wealden beds yield fossils of most of the above species, including bones and footprints of the Iguanodon and Hypsilophodon; while the so-called 'lobster bed,' with numbers of the crustacean *Meyeria magna*, forms part of the Atherfield Clay.

Chalk Formations. The really outstanding feature of the Cretaceous period was the wide spread of sea over land, the greatest taking place during the deposition of the various beds of the Upper Cretaceous series. The process occupied millions of years; thus we find a succession of facies of a very different character revealing the conditions of deposition. The lowest, consisting chiefly of dark bluish marine clays, intercalated in places with sands and chert beds, indicate the wearing down of the land and cliff face of those days, and the deposition of the argillaceous sediment along the margin of the encroaching sea-bed. This deposit is known as *Gault*. Above, following this, is a sandy deposit of greenish and sometimes yellowish hue produced by the wearing away of hard rocks of a former age and the redepositing of them along the sinking shore line of Cretaceous times. This deposit is the Upper Greensand and, together with the Gault, is palaeontologically known as *Albian* and geologically as *Selbornian*. These are followed by the great series of calcareous deposits, known collectively as the chalk, which is divided into Lower Chalk or Cenomanian; Middle Chalk or Turonian; and Upper Chalk or Senonian and Campanian, the second terms being now used as a rule.

Gault Deposits. Gault is essentially an arenaceous deposit of marine sediments with occasionally sandy marls, overlain with Upper Greensand. The whole is now regarded as one formation and attains a thickness up to about 300 feet, reaching 200 feet at Maidstone and increasing to the west through Kent and Surrey to Hampshire, where, near Selborne, it is nearly 250 feet in thickness. It appears in Wiltshire and the Isle of Wight, where along the famous Undercliff the Gault clays, sands and chert beds attain a thickness of 240 feet. It is also well displayed at Folkestone in the Warren undercliff; and in Dorset and Devon, in parts of the cliffs between Lyme Regis and Sidmouth, where it attains a thickness of about 150 feet and is prolific in fossils. In various localities between these towns and the Blackdown Hills the Gault appears above the Triassic and Liassic formations. In Berks and Oxon the Gault clays and marls reach 300 feet in thickness. North-eastward this thins out to 150 feet in Cambridgeshire and to 60 feet in the Stoke Ferry area of Norfolk. Farther north the Gault clays change into the thin beds of 'red chalk' so strikingly exhibited in the cliff face at Hunstanton, where they are, however, only between 3 and 4 feet thick. These beds appear in Lincolnshire, where at Willoughby they total about 12 feet thick, and reappear in Yorkshire, where at Speeton Gap they attain a thickness of 30 feet, but thinning out westward. Farther north than Bedfordshire the Upper Greensand and distinctive Gault deposits are gradually replaced by clays, which finally become the reddish marls known as Red Chalk.

Chalk Deposits. Chalk is probably the most easily recognized of all deposits; it is a very friable limestone, composed chiefly of foraminiferal ooze. The shells of these tiny organisms, deposited in the course of millions of years on the ocean floor, gradually built up the massive beds over 2,000 feet thick, which are now largely high and dry around the shores of Britain, and from which it was called Albion (Lat. *albus*, white). This foraminiferal deposit is still taking place in the bed of the Atlantic and elsewhere, the genus *Globigerina* entering largely into its composition now as it did then. There are several varieties of chalk, deposited after long intervals of time, and, therefore, under different conditions and after considerable evolution of life forms.

The *Lower Chalk* has at the base a sandy marl with glauconite grains giving it a greenish hue similar to the Greensand facies; the Lower Chalk is also known as Grey Chalk, owing to the amount of clayey material in its composition. Numerous fossil sponges, ammonites, particularly *Schloenbachia varians*, and many other fossils occur. Above are deposits of soft grey marl with belemnites in profusion. This constitutes the Cenomanian zone, the name being given because the beds were first recognized in the Le Mans area of the ancient Cenomanni. The Lower Chalk extends over most of the area of south-east England, beneath the superimposed strata, from Wiltshire and Dorset to Norfolk and Suffolk, being absent only in the Wealden and Lower Greensand area of Surrey, Sussex and Kent. It consists collectively of a bed about 250 feet thick in Wiltshire, decreasing gradually to about 60 feet at Hunstanton, and thinning out further in Lincolnshire and Yorkshire. It is well presented at Folkestone, and also in the Culver Cliffs of the Isle of Wight, where the Lower Chalk attains a thickness of about 200 feet. In Europe it extends eastward into northern France, Belgium and Germany to Bohemia while southwards it covers most of southern Europe.

The *Middle Chalk* or Turonian consists of a massive bed of white chalk resting upon a layer of hard nodular chalk, which in turn overlays the soft marl of the Lower Chalk series. The lower portion of this white chalk is without flints, while the upper part is often stratified with flints; it is well presented in cliff faces on the south and east coasts and attains various thicknesses—150 feet at Compton Bay, nearly 200 feet in the Culver Cliff of the Isle of Wight, at Ballard Cliff in Dorset about 120 feet; and gradually thickening eastward it reaches nearly 250 feet near Dover. On the east coast the Middle Chalk series are presented in Norfolk and Lincolnshire about 100 feet thick, but near Speeton in Yorkshire they increase to over 200 feet. Generally they overlie the Lower Chalk series throughout S.E. England and elsewhere.

Upper Chalk Beds. The Upper Chalk series are remarkable for the layers of black flints with which they are stratified. These flints are siliceous concretions which often contain silicified fossil shells and fragments as a central nucleus.

The massive white face of the Upper Chalk approaches the surface over an extensive area of England. This colossal bed of chalk is exposed at various places round the English coast, and in many railway cuttings and numerous quarries. At the Needles and cliffs of Afton Down in the Isle of Wight it is well presented, attaining a thickness of over 1,300 feet. Westward in Dorset it averages about 1,000 feet, and it also appears throughout the Sussex chalk area, reaching to about 900 feet

THE NEEDLES. A colossal bed of chalk lies beneath the surface of a great part of eastern and southern England. It is well exposed along the coasts of Kent and Sussex, and also in the Isle of Wight—largely composed of chalk—where this photograph of the famous Needles was taken. Beyond the outermost of the three sharp-pointed pillars of white chalk may be seen the Needles lighthouse.

SLUGGISH BRONTOSAURUS. *One of the vastest of all quadrupeds, this gigantic reptilian animal was a vegetable feeder. It probably spent most of its time wading in shallow estuaries but may sometimes have walked on dry land.*

Reconstruction by courtesy of the American Museum of Natural History

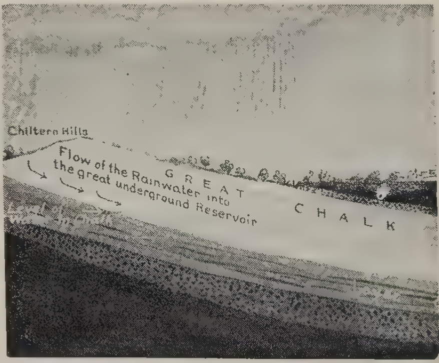
in thickness. It comprises the cliff face of Thanet and the North and South Forelands, extending from St. Margaret's Bay to near Walmer, the thickness of the bed in these areas being about 500 feet. In Suffolk and Norfolk, the Upper Chalk reaches about 1,100 feet; in Yorkshire, where it is well presented at Flamborough Head, it is over 1,000 feet thick.

The Upper Cretaceous beds are but little in evidence in Scotland, having been saved from denudation in a few isolated areas by subsequent lava flows in Mull and the adjoining Morven district. The same applies to Ireland, where the Upper Cretaceous beds appear as an encircling fringe of white cliff beneath the black basalt which covers Antrim.

The Campanian facies of the Upper Chalk constitutes the last and uppermost of the Cretaceous series found in England, but there is yet another deposited later, the Danian, named from East Denmark, where it is well shown, though found also in Sweden and a few patches elsewhere in northern Europe. The Danian represents the only transition beds remaining which connect the Cretaceous with the Eocene, some of the fossil types of the former passing up into the latter; thus is bridged the break between the last period of the Mesozoic era and the first of the Tertiary.

Cretaceous Flora and Fauna. The flora of the Cretaceous period had already begun to assume the types prevailing today, and while the ferns such as *Asplenium* and *Gleichenia*, cycads, palms and various conifers, such as juniper and others of earlier periods, flourished, angiosperms had appeared in profusion. Dicotyledons must have been evolved earlier, for they are found perfected and in abundance at this period—the oak, beech, plane, poplar, fig, maple, willow, magnolia, gum tree, cinnamon, buckthorn, ivy, laurel, walnut, alder, cassia, and many others indicative of the long period of time that must have been spanned by the Upper Cretaceous age, probably at least twenty million years.

Reptilian Developments. It is the fauna of this age which exhibited such an amazing development, particularly in its reptilian forms. These evolved into giant species and the largest land animals that ever existed, but all save a few diminutive types vanished toward the close of the period. Such were the huge land reptiles, the dinosaurs. The herbivorous *Brontosaurus* attained a length of 80 feet and a weight of between 30 and 40 tons. Other herbivores were the stegosaurs (plated lizards) such as *Monoclonius*. Giant carnivorous dinosaurs preyed upon these—*Tyrannosaurus*, 30



LONDON'S CHALKY BASE. *Some 250 feet below London's streets, separated from them by layers of clay, grey sand and shingle, is a bed of chalk, 600 to 700 feet in thickness, which comes to the surface in* feet long, and the *Allosaurus*. The sea also had its giant reptiles, the *Mosasaurus* attaining 75 feet in length, and the great sea-snake, the *Discosaurus*, a length of 40 feet; others were the *Dolichosaurus* and the *Coniosaurus*. The air had its great reptiles, the *Pterosauria*, of which the strange pteranodon and the *Ornithocheirus* are examples.

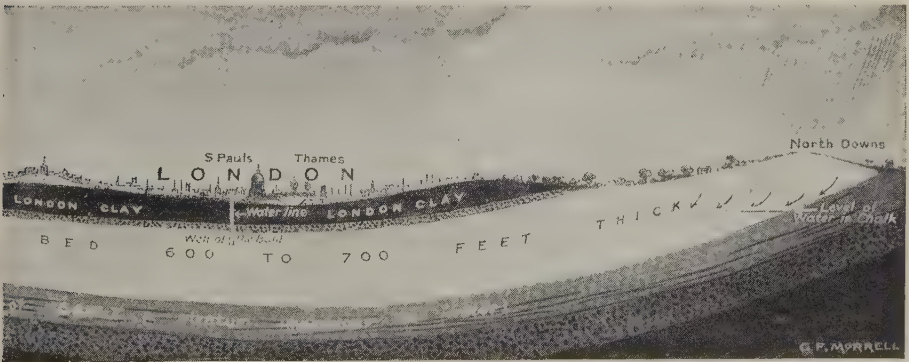
Great toothed birds such as the *Hesperornis* 6 feet in length, the *Apatornis* and *Ichthyornis*, smaller varieties resembling the ostrich, but all with reptilian skulls, were plentiful; only remains of the *Enaliornis* have so far been found in the English Cretaceous beds. Small mammals continued to maintain an existence, but remains of them are very rare, the cretaceous deposits being largely marine.

Tropical Climates. The worldwide semi-tropical climate of those times was particularly conducive to flourishing life; even in north Greenland tropical ferns, figs and magnolias flourished. The seas teemed with life all tending to abundance of giant forms. The cephalopods, ammonites and belemnites were most prolific and remarkable for size and variety. The lamellibranchs also attained profusion, the Hippurites largely composing the great worldwide beds of hippuritic limestone extending over southern Europe, south-west Asia, India, Texas, Mexico, and California. Other species were *Trigonia*, *Nucula* and *Inoceramus*. The brachiopods *Terebratula* and *Rhynchonella* were most prolific, together with sponges, more particularly *Ventriculites*, *Camerospongia* and *Doryderma*; while the sea-bottom was covered with sea-urchins, chiefly *Echinoconus*, *Ananchytes*, *Cardiaster*, *Marsupites* and *Micraster*. Innumerable teeth of various species of sharks, *Lamna*, *Oxyrhina* and *Otodus*, are found, together with fossil remains of modern species of teleostean fishes such as cod, herring and salmon.

TYRANNOSAURUS.* *This carnivorous dinosaur was between 30 and 40 feet in length, including the tail. Its jaws were furnished with terrible sabre-like teeth.

American Museum of Natural History

Apart from its lime products, the Upper Cretaceous system of porous chalk strata is of great economic value as a source of reserve water supply; for since these beds are usually over clay beds which are non-porous, vast natural reservoirs are thus created and are well adapted for artesian well-sinking where synclines exist, as in the Thames basin and many areas in south-east England. Experiments in Australia and the United States, have shown that large waterless areas may thus be made fertile.



the Chilterns and North Downs. Below the chalk is a layer of gault, and as this is impervious to water, the rain-water is retained in the chalk, which thus constitutes a vast natural reservoir. An inch of rain yields 14½ million gallons over one square mile, and a fifth of London's water supply is obtained by means of artesian wells sunk down to the chalk.

LESSON 17

First Periods of the Cainozoic Era

The Tertiary or Cainozoic era (Gk. *kainos*, recent, *zoe*, life) is the era of recent life-forms as distinct from those of the Mesozoic era, which terminated with the Upper Cretaceous times. The Cainozoic era embraces the last ten to possibly twenty million years, and it is divided into four periods:

(1) Eocene—'Dawn of recent' species;
(2) Oligocene—'Few recent' species;
(3) Miocene—'Less recent' species;
(4) Pliocene—'More recent' species.

The first two compose the Lower Cainozoic or Palaeogene division and the last two the Upper Cainozoic or Neogene division. Some authorities add two periods to the Neogene division; these are: *Pleistocene*—'Most recent' species; *Neocene*—'New' species. Other authorities allow these two periods to constitute the Quaternary era, the present Age of Man.

Throughout the Mesozoic era the vast central sea or ocean known as the Tethys had occupied the great Mediterranean basin, north Africa and the whole of central Asia as far as China. There were no Himalayas in those days, no Caucasus, Alps, Carpathians, Balkans or Apennines, no Pyrenees or Atlas mountains, and no Downs or Pennine range in England. Over this area, from the ancient mountains of Wales, the west of England and Scotland, which linked up with Scandinavia, to the southern boundary of what is now the Sahara, was this vast waste of waters, which had increased considerably during the Cretaceous period.

A great uplift of the sea bed had set in toward its close and a resuscitation of volcanic activity; these were involved in seismic stress and strain which, toward the middle of the Tertiary era, were to result in the colossal crustal folds and the formation of the above-mentioned mountain ranges. But some millions of years intervened before the great calcareous deposits rose above the sea level here and there, thus producing peninsulas and islands, which later formed the numerous countries surrounding the modern Mediterranean littoral.

One such island had risen in a large and partially enclosed sea, which covered south-east England, the north of France from Normandy to the Ardennes and the Netherlands; this sea is therefore known as the Anglo-Gallic basin. The island rose as a great dome, attaining a height of over 1,000 feet, and extended from Hampshire to Artois, across what is now the Strait of Dover, and is known as the Wealden Island. It was composed of a great anticlinal fold of chalk; subsequent denudation eroded the centre down to the Wealden strata, forming the valley of the Weald and leaving the escarpment of the remaining chalk beds to constitute the North and South Downs.

Eocene Classification. Meanwhile the lowest of the Eocene beds were beginning to form as shallow water deposits and, later, as estuarine and deltaic sediments—the result of the denudation here and in the mountainous regions to the north and west. These deposits were gradually spread over south-east England, northern France and Belgium, composing one vast extending layer of various kinds of sands and clays, which in Eocene times attained a thickness of over 1,500 feet in south-east England. They are classified and constituted as follows:

Thanet Beds. Immediately overlying the Cretaceous are the lowest of the series, composed of sands, pale or greenish, with some sandy marl and numerous fossils; the beds are well exposed in the cliffs of Thanet and Pegwell Bay and attain a thickness of 60 feet, thinning to 50 feet in west Kent and vanishing in Surrey.

Woolwich, Reading and Oldhaven Beds. These consist of marine and estuarine sands with grey clays, attaining a thickness of between 100 and 150 feet; between Reading and the Isle of Wight at Whitecliff Bay.

London Clay. This is a bluish-grey clay changing to a brown tint on atmospheric contact and containing layers of septarian nodules. The clay attains a thickness of about 500 feet beneath London, but thins out and becomes more sandy towards the west, being only 50 feet thick at Newbury. It remains thick in the Hampshire area, reaching nearly 300 feet thick at Portsmouth and in the Whitecliff and Alum Bay area of the Isle of Wight. Its abundant fossils are a curious mixture of marine and land types; these include fishes, molluscs, crustaceans, turtles, crocodiles, sea-snakes, sharks, remains of birds, small plants, palms, modern trees and many varieties of mammals.

Bagshot Beds. Sands which have been largely eroded and therefore remain in patches over the London Clay, compose these beds; they are present over the Bagshot, Aldershot, Farnborough, Wokingham and Ascot areas and attain a thickness approaching 150 feet in the Bagshot district. North of the Thames they are much more denuded, occupying small areas at Highgate, Hampstead and Harrow, on the high ground. In the Hampshire area and that of Alum Bay in the Isle of Wight the light coloured sands are laminated with clays and attain thicknesses varying between 300 and 600 feet.

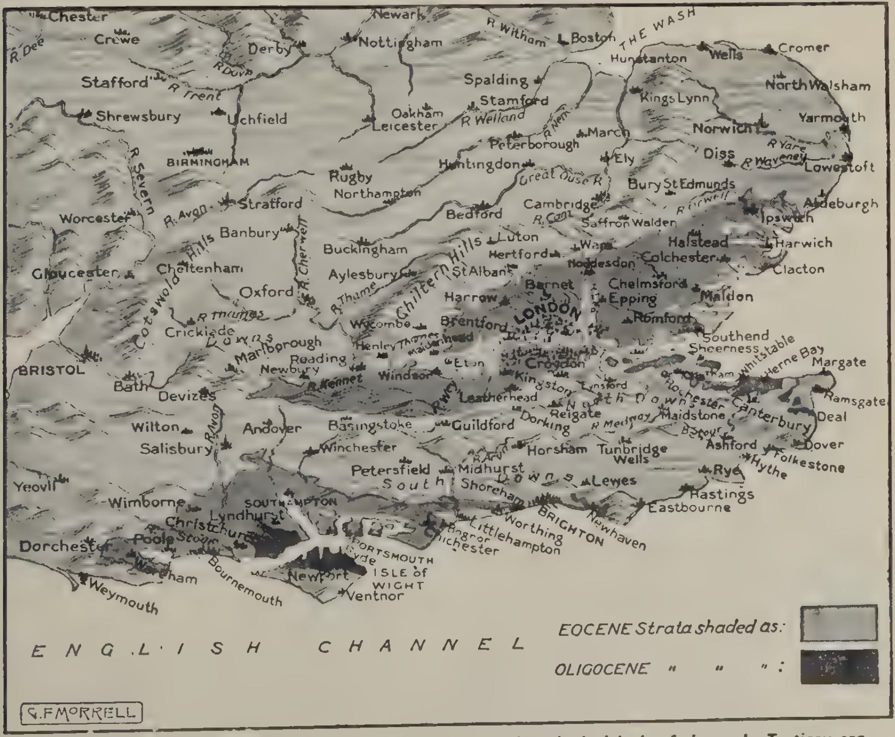
Bracklesham and Bournemouth Beds. Composed of laminated clays and sand, these beds are between 200 and 300 feet thick. They are well presented at Bracklesham Bay in Sussex, at Whitecliff Bay in the Isle of Wight, at Bournemouth and at Hengistbury Head. The sands and clays of this series exceed 500 feet in thickness in this area.

Barton Beds. These consist of alternating layers of sands and clays. They are nearly 200 feet thick at Barton, where they are well shown to the east of Christchurch, and also at Alum Bay and Whitecliff Bay, where they exceed 300 feet.

Oligocene Period in England. Above the Eocene series are further thinly bedded deposits of sand, clay, marls and thin limestone layers in the Isle of Wight and New Forest areas. These are the only representatives of the Oligocene period in England, but in Germany they constitute thick and extensive beds forming a long and important geological period. During this time nearly the whole of south-east England and northern France had been lifted above the sea and, consequently, there were no deposits; but the German area, which had remained uplifted during the Eocene period, became submerged during the Oligocene and so obtained the deposits missed in the Eocene.

The Oligocene is practically a later continuation of similar Eocene conditions, which in the above small areas are represented by the following series:

The Headon and Brockenhurst Beds. These are composed of clays and sands intercalated



EOCENE AND OLIGOCENE PERIODS. *Sites in England of geological beds of the early Tertiary era.*

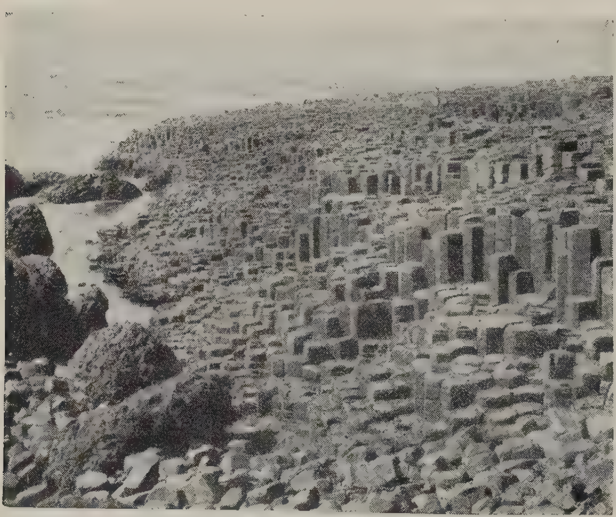
with thin beds of limestone, the whole comprising a marine facies and approaching 150 feet in thickness. Well exposed at Headon Hill and Whitecliff Bay; extending beneath the New Forest, Brockenhurst and Lyndhurst.

The Bembridge Beds. Composed of freshwater marls over the Bembridge limestone, which in turn overlies the Osborn marls, these beds form three divisions of freshwater and brackish deposits, which together attain a thickness of about 200 feet.

The Hamstead Beds. Composed of marine deposits of marls and clays with numerous fossils of land plants, indicating an estuarine origin, the beds altogether attain a thickness of about 250 feet.

In addition to the Hamstead Beds, which are the uppermost of the series, there are in the Bovey Tracey area of Devonshire a series of freshwater sands and clays which, from the fossil plants found embedded, suggest formation in late Oligocene times, though they have been ascribed to the succeeding Miocene period.

Over southern Europe the Eocene deposits were most extensive and attained a thickness of 3,000 feet in many areas. They consisted largely of nummulitic limestone, so named from the great proportion of the remarkable nummulites, or disk-shaped foraminifers, entering into its composition. These massive beds extend from the Pyrenees to the Caucasus and Egypt.

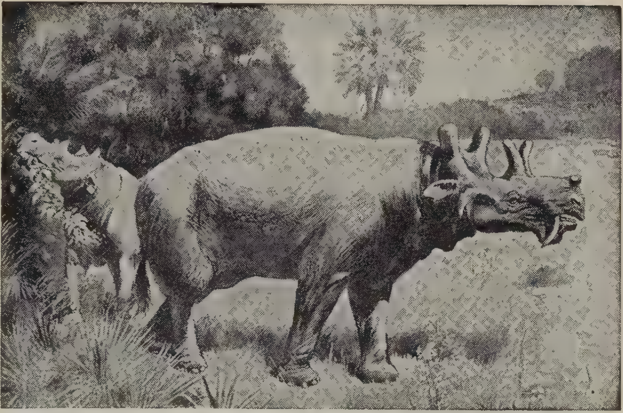


THE GIANT'S CAUSEWAY. This promontory of columnar basalt on the north coast of Antrim, Northern Ireland, really comprises three causeways—the Little, the Middle or Honeycomb, and the Grand (shown in this photo)—separated from one another by upthrusts of shapeless basalt called whindikes. Some 40,000 polygonal basalt pillars (diameter 15-20 ins.) are closely packed in the Causeway area.
Photo, W. Lawrence

Volcanic Eruptions. A great recrudescence of volcanic activity occurred in Eocene times over large areas of northern Britain and Ireland, which were then united in a land mass, probably with Iceland and Greenland. From Mull to the volcanic cone of far St. Kilda, possibly to the Faroes, and from the Antrim mountains to Skye, vast lava sheets were spread out from the great volcanoes rivalling the present Etna in magnitude, and of which Ben More of Mull is but a denuded stump. This volcanic activity synchronized with the general upraising of north-west Europe. An area over 2,000 square miles in extent, comprising nearly the whole of Antrim and much of Down and Derry, is covered by two immense sheets of basaltic lava totalling over 1,000 feet in thickness, overlying the chalk beds of the preceding period. Along the Antrim coast the gigantic black cliffs formed by the basalt are a most impressive feature, particularly along the northern coast, where the basaltic lava forms many picturesque and symmetrical columns generally hexagonal or pentagonal, and divided horizontally into countless perfect-fitting sections. Over 40,000 of these gigantic pillars are visible in the district known as the Giant's Causeway.

Similar outpourings extended over what is now the sea as far as Mull and other islands of the Inner Hebrides, of which the beautiful Staffa is the most famous (*see* page 75). The eruptions were spread over long intervals of time—probably more than a million years.

Fossil Remains. The great saurians and amphibians, such as the *Brontosaurus*, *Megalosaurus*, *Stegosaurus*, *Mosasaurus*, the plesiosaurs, ichthyosaurs and pterosaurs completely vanished and only a few diminutive species remained, the Tuatera alone surviving to present times. The ammonites, belemnites, hamites, hippurites and many other varieties died out entirely. In their place totally different types of animal life had not only appeared, but attained perfection and differentiation. It is as if another world of life was entered which had already existed for several millions of years. Birds had appeared in great variety, though fossils are scarce, while mammals had completely supplanted the saurians.



DINOCERAS: AN EOCENE MONSTER. Most of the little mammals of the early Eocene period progressed in complexity and brain-power till they became the creatures we know today, but some advanced in bulk without any increase in the size of their brain. The latter—of which the Dinoceras ('Terrible Horn') of North America, seen in this reconstruction, was one—in course of time were exterminated by their better-equipped rivals.

Reconstruction by C. R. Knight, American Museum of Natural History

This fauna was adapted for a warm climate, the most noteworthy types being various tapir-like animals, the *Palaeotherium*, *Coryphodon*, *Lophiodon*, *Paloplotherium*, and *Pachynolophus* of the rhinoceros type, also the *Hyracotherium*, a cony-like creature, and the carnivorous *Palaeonictis* and *Arctocyon*. The *Dinoceras*, *Arsinoitherium* and *Hyaenodon* also supplanted the colossal dinosaurs. A stranger had appeared in the form of the lemuroid *Microchaerus*, the first known primate and possible ancestor of Man.

LESSON 18

The Folding Miocene and Pliocene World

THE Miocene and Pliocene periods taken together are now regarded by many authorities as two series of the Neogene system of Tertiary deposits; nevertheless, they were totally dissimilar periods, though the strata and life forms merge as a rule without distinctive break. There are scarcely any deposits in Britain of the Miocene period, the only evidence being the fossil types in the lacustrine deposits of the Bovey Tracey area in Devonshire, and in some small deposits in basaltic hollows of the west of Scotland and elsewhere.

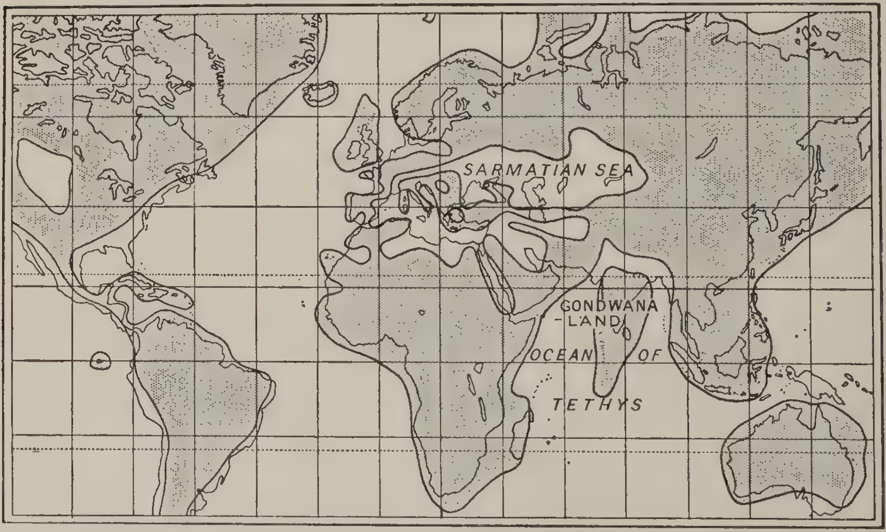
The Miocene deposits are, however, extensively presented in the continent of Europe, more particularly in the Touraine area of France, in Belgium, over most of Germany, Austria, Switzerland between the Jura and Alps, north-east Spain, Italy, eastern Europe; also in Syria, Egypt, Arabia, Persia, India; in the Atlantic States of North America and in the Pacific States. Here they are known as the Monterey beds and attain a thickness of between 6,000 and 7,000 feet. The shales of this series reach to 4,000 feet, and are of great value on account of their oil-bearing properties. The Miocene beds are uplifted to high altitudes in the Rockies, indicative of the chain's recent raising.

While practically the whole of Britain, Ireland and the north of France were above sea level in Miocene times, and so have left scarcely any deposits, a general upraising of vast submerged areas continued from the Oligocene and Eocene periods. So in the course of the Miocene age—probably at least 5,000,000 years and possibly much more ago—the vast Ocean of Tethys (*see* map of Miocene times in next page) was divided into what are known now as the Indian Ocean and the great Mediterranean area by the upraising of Asia Minor and the Arabian, Persian and Syrian regions of south-west Asia. Egypt and North Africa followed, while a colossal folding of the earth's crust began and continued generally in an east and west direction.

Folds in the Earth's Surface. This folding extended its course from the downland of Britain to what is now China; out of the vast sea that had existed for some hundred million years these great folds of a shrinking earth arose to form the enormous mountain chains of the Himalayas, the Caucasus, Taurus and mountains of Persia, Arabia and Baluchistan. The Alps, Carpathians, Apennines, Pyrenees, all formed part of this the most colossal fold of the earth's crust, the loftiest and most far-reaching that is ever known to have occurred. Curving southward, through the Sierra Nevada of Spain, it crossed at the place where is now the Strait of Gibraltar and formed a southern and lesser fold constituting the Atlas Mountains from Morocco to Tunis. Subsidiary folds accompanied the lines of the main fold in a series of thrusts and overfolds, which extended as far north as the downs of the Isle of Wight.

Ancient Seas. Deep and shallow areas remained between these gigantic walls of raised sea bed; some formed arms of the now much restricted Mediterranean or Central Sea, while one across southern France formed a wide strait connecting the sea with the Atlantic for a time. North of the ascending Alps large areas of the former sea remained and formed a series of great shallow lakes, known as basins, which gradually became freshwater lakes; one covering an Austrian area is known as the Vienna Basin and another in the Rhine area as the Mainz basin, while Switzerland mainly formed a great lake between Alps and Jura.

The great Sarmatian Sea remained as the western remnant of the vast Tethys Ocean, with the recently upraised Himalayas and Baluchistan mountains dividing it from the Indian Ocean, the third and southern remnant. This Sarmatian Sea spread as a shallow waste of waters from the Carpathians to the Himalayas; it also gradually shrank into a series of great basins, the present-day remains of which constitute the Black Sea, Caspian and Aral Seas and numerous drying-up salt lakes.



MIOCENE AGE. Land masses of this remote period are shown stippled and outlined in black.

In England the extensive syncline which now forms the basin of the Thames, with the Chiltern Hills composing its northern rim and the Downs its southern, came into existence as the result of this upraising and crustal folding. At first a broad synclinal depression extended to what is now the Severn estuary, and constituted a long channel connecting the North Sea with the Atlantic Ocean, the present English Channel being then non-existent. By this means warm waters were able to penetrate into the North Sea with living forms adapted thereto. At a later date only organisms flourishing in colder waters existed in that sea, showing that the increasing upraising of the land had closed the channel. So an inlet of the North Sea was first formed, and then came the verdant valley through which the Thames and its tributaries meandered. As this upraising of the land continued into the succeeding Pliocene times, the North Sea of those days itself retreated and a broad plain took its place. The Thames then became the tributary of a much larger river flowing north and a continuation of the predecessor of the Rhine.

In the western hemisphere, as in the eastern, continental masses were approaching their modern form. Most of the colossal upraising of the Andes and Rocky Mountains occurred during this Miocene period. Salt lakes formed between the Pacific and the uplifted ranges in the extensive valleys of the synclinal folds. The Great Salt Lake in the state of Utah is the largest survivor of these basins but very much diminished.

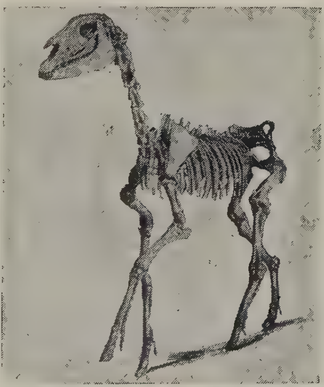
Africa having become united to Eurasia by the upraising of Arabia and connexions with southern Europe, Australia remained as the only segregated continent surviving from pre-Miocene times, with the result that its fauna and flora were from henceforth practically distinct and remain so to modern times. Nevertheless, it shared in the world-wide upraising of the land, as the Miocene deposits of Victoria and Tasmania testify. New Zealand also has large areas of both North and South Islands covered by Miocene deposits.

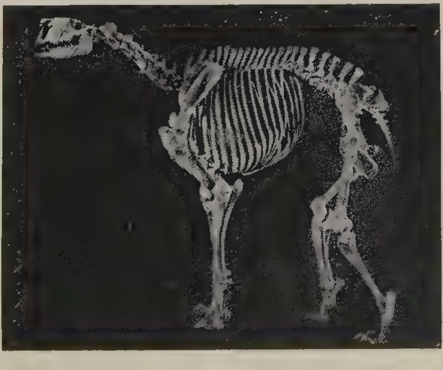
Pliocene Period. Thus it may be seen how extensive was this crumpling of the earth's strata, which continued into Pliocene times and, in many areas, still continues as an upraising process with corresponding depressions in other regions, though the conditions now appear to be stabler. A general recession of the sea continued through Pliocene times, and, except for some areas of subsequent submergence on a lesser scale, such as the North Sea and the local ravages of coastal attrition, the sea undoubtedly appears to be still diminishing.

The Pliocene period is probably not much more than a million years distant; it is practically a continuation of the Miocene, modified by climatic and local influences, which brought about new forms of animal and plant life, with the extinction of some of the older species of animals and a transference of others to warmer latitudes. Thus a distinctive series of deposits may be recognized as constituting the Pliocene.

They occupy a large tract of east Norfolk and Suffolk, with the adjoining north-east corner of Essex. They are present as sand and clay at St. Erth in Cornwall.

Over the continent of Europe the Pliocene deposits attain a thickness of about 1,200 feet in Holland, where they are extensive. They constitute a large proportion of Italy each side of the Apennines to the sea, and reach a thickness of 2,000 feet in Calabria and Sicily. In Austria, Greece and around the Mediterranean they form a fringe of beds of varying thickness and often lacustrine origin.





***FAUNA OF THE MIOCENE.** Fossilized skeletons of: top, Hippotherium or Lipparion; below, Mastodon (left) and (right) Moropus ('sloth-foot').*

American Museum of Natural History, New York

The Pliocene beds in England are divided into the following series:

Upper

Cromer Beds (uppermost): the 'forest bed' of peat and tree-trunks, freshwater sands and silts. Exposed from Happisburgh to Weybourn.

Weybourn Crag: sand, loam and blue-clay, a marine shelly deposit found at Weybourn.

Chillesford Beds: finely laminated clays and sands: traced as a sinuous band from Walton-on-the-Naze to Mundesley over the underlying beds.

Norwich Crag: gravel and shelly sand deposit with laminated clays between 150 and 200 feet thick at Lowestoft and Southwold, where it appears at the base of the cliffs.

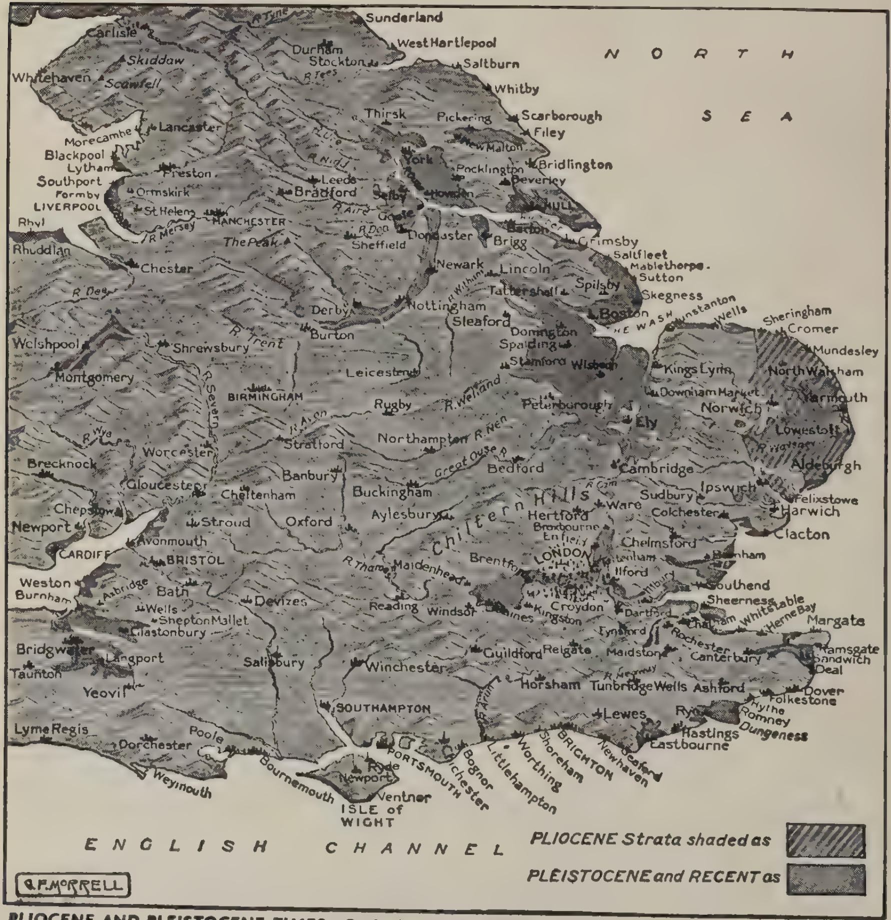
Middle

Red Crag: ferruginous shelly sand, the peroxide of iron producing its distinctive colour. Covers an area between Ipswich, Felixstowe and Walton-on-the-Naze, but only well exposed in valleys and cliffs at Walton, Bawdsey and Felixstowe.

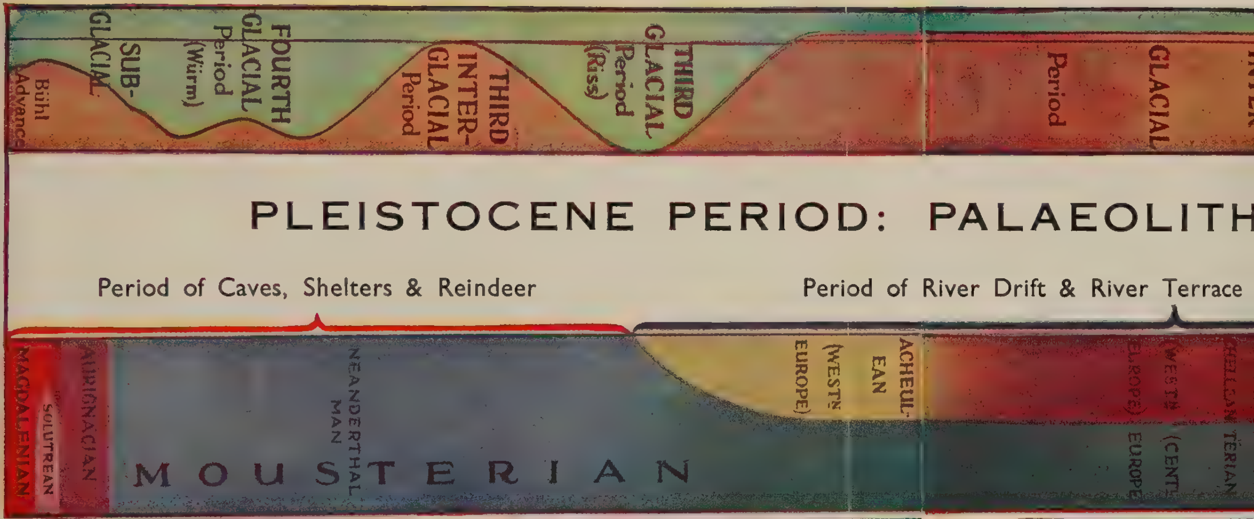
Lower

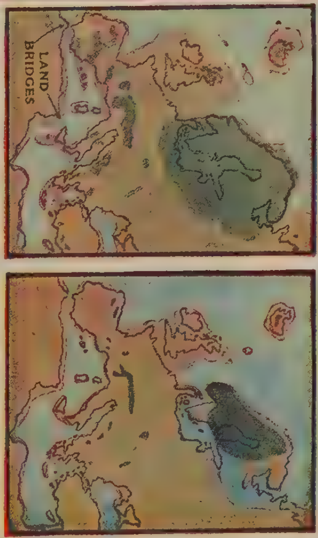
Coralline Crag: fragments of corals, molluscs, crustaceans, with numerous remains of animals, fish and reptilian vertebrae—all apparently washed out from pre-existing beds. Found between Aldeburgh and Boyton, also in patches elsewhere.

Lenham Beds: lowest and oldest of Pliocene deposits; brown clay, red and yellow sand and flint pebbles. Only fragmentary remains exist now on the downs between Folkestone and Maidstone. Fossil types indicate age.

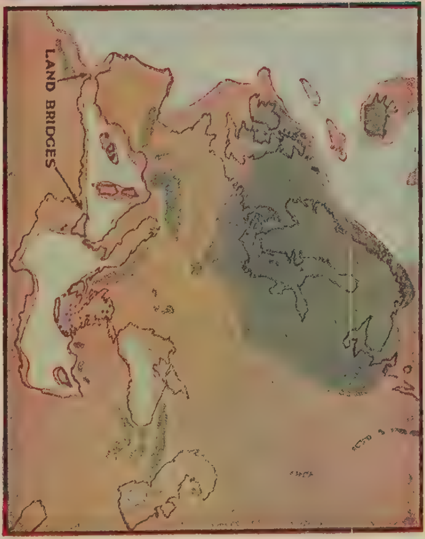


PLIOCENE AND PLEISTOCENE TIMES. **Geological remains in Britain before and during the Great Ice Age.**

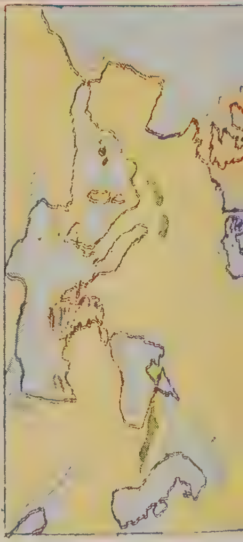




FOURTH GLACIAL PERIOD. The land bridges across the Mediterranean that characterized the glacial periods played an especially important part in man's story during the Würm. On the left is the main glaciation, on the right the secondary phase (or 'oscillation') known as the Bühl advance.



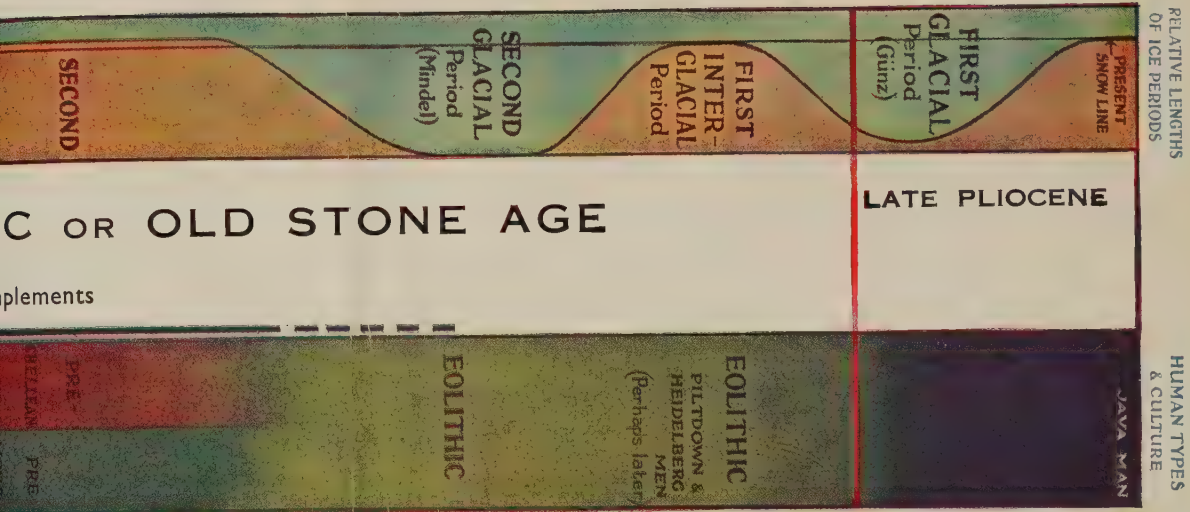
THIRD GLACIAL PERIOD. The Riss glaciation probably did not cover as much of the British Isles as the Mindel. It should be observed that green denotes the actual ice caps and glaciers only, and that most of the remaining country must have been involved in a thoroughly Arctic climate.



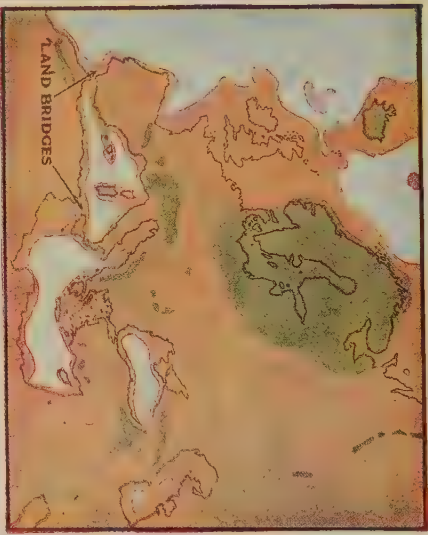
SECOND INTERGLACIAL PERIOD. Though the longest and warmest of the interglacial periods, this may be taken as typical of the others. It used to be thought that the land during these clement intervals was at maximum elevation, but the latest evidence favours the opposite view.

MAN DURING THE ICE AGES. The chart given in this folder covers Europe and the Mediterranean region. In it the evolutionary story is carried from the beginning of the Ice Ages in the Late Pliocene to the development of the later Palaeolithic cultures after the ice had begun to retreat at the close of the fourth Glacial Period. In the first column are indicated the successive glacial and interglacial periods and their approxim
to which the ice descended upon the e
snow line. Next, we have the corresp
in the third column the succession of
and receded. A table given in page

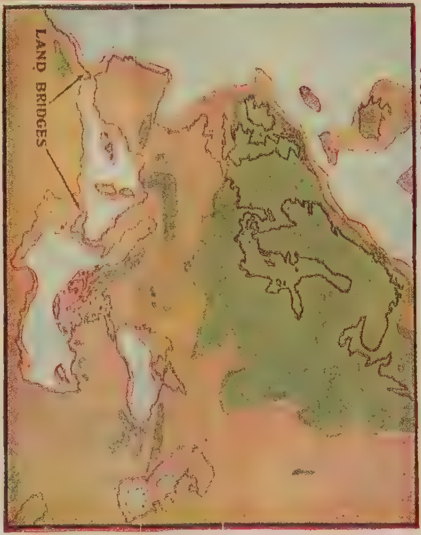
To face p. 128



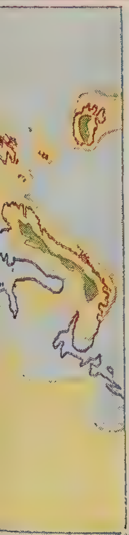
HOW THE ICE SHEETS ADVANCED AND RECEDED DURING THE FOUR GLACIAL PERIODS



FIRST GLACIAL PERIOD. This, known as the Günz glaciation, was, as one might expect, the mildest of the four glacial periods. It did not involve the British Isles, but a study of Alpine and of Scandinavian sites has established its identity. Note the differences from the modern coastline.



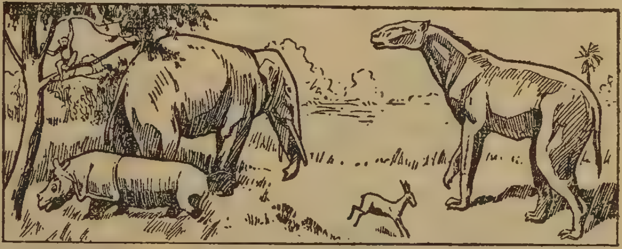
SECOND GLACIAL PERIOD. Far the most serious glacial advance is known as the Mindel. In this and the Günz much land emerged round Iceland, but although it was probably in large part under ice, the available evidence only allows us to give Iceland itself the green colour denoting glaciation.



e relative lengths, as well as the extent
th's surface as measured by the present
nding human types and cultures, while
aps shows how the ice sheets advanced
11 of Vol. I amplifies and extends the

later portion of the chart from the Aurignacian period through the last return of the ice in the Magdalenian period down to historic times. The chart as a whole has been produced under the general supervision of Professor H. J. Fleure, and the glacial maps are based on material in 'Corridors of Time' (Oxford University Press), by H. J. Fleure and H. J. E. Peake.

The life of the above series indicates an increasing number of northern forms adapted to colder and colder conditions, while a growing decrease in those suited to a warm climate is evident.



FAUNA OF MIOCENE AND PLIOCENE TIMES. *Below, rhinoceros, mastodon (a precursor of the elephant) and the extinct Chalicotheres (right), pastured on the grassy plains of Miocene times, as well as anthropoid ancestors of the gorilla, chimpanzee and Man. Above, ancestral forms of all living animals were in evidence during the Pliocene Period.*

Fauna and Flora. The world-wide warmth of the Miocene period, which in England and throughout Europe caused a sub-tropical flora to flourish, is as difficult to account for as the subsequent glacial invasion of the Pleistocene period. Even in north Greenland within 700 miles of the Pole sub-tropical evergreens flourished; seams of coal 30 feet thick testify to its long duration.

In late Miocene times the vegetation became of a more temperate type and a change is perceptible in the fauna. Beeches, poplars and hardy evergreens, such as laurels, took the place of the palms, myrtles, mimosas, fig trees and magnolias of the earlier time; while monkeys, which had made their appearance, retreated south over a thousand miles.

The fauna of Miocene times is remarkable for the elimination of marsupials from Europe and the coming of the ape, the *Machaerodus* or sabre-toothed tiger (lion), the giant Proboscideans, Dinotherium and Mastodon, the latter developing into *Elephas meridionalis*, *Elephas antiquus* and *Elephas Jeffersonii* in Pliocene times. Bears, hyaenas and species of rhinoceros, hippopotamus and tapirs approaching present-day types, developed, together with the *Anchitherium*, an ancestor of the horse, and its near relatives the *Hippothenium* and *Moropus*. The listriodon, a pig-like creature, the giant ant-eater *Macrotherium*, and *Amphicyon*, an ancestor of the dog, had also appeared; while, perhaps the most important, the great anthropoid apes *Dryopithecus* and *Pliopithecus* now made their appearance. (For the evolution of the horse *see* Biology, Vol. II, Lesson 20.)

In the Pliocene period the *Mastodon tetrabelodon* had appeared, while numerous wolves and horned deer (*Cervidae*) developed from the Dicroceras of Miocene times. Wild asses, the Hipparion species, and herds of antelopes appeared, but the Dinotherium and others vanished, never to return.

LESSON 19

The Ice Ages

THE last period of the Cainozoic era covers what some geologists call the Quaternary era. It extends back between 500,000 and 1,000,000 years, and is divided into two geological periods—the earlier being the Pleistocene, or mostly recent, and the later the Holocene, or recent. This brings the palaeontological record down to archaeological and historical times. The Pleistocene deposits indicate a method of deposition largely due to ice and frigid conditions. The Pleistocene is therefore known also as the *Glacial Period* or the Great Ice Age, though since large temperate and tropical areas remained free from these conditions, the deposits in such areas are normal and generally resemble those of the later Pliocene period.

The evidences for these frigid Arctic conditions are chiefly the extensive masses and piles of detritus peculiar to glaciers indiscriminately spread over exposed strata of various other geological periods. Other evidence is the effect produced by the weight and movement of the enormous glaciers as they pass over the various surfaces of the underlying beds.

Pleistocene Glaciers. In Pleistocene times even mountains were buried under vast moving ice sheets compounded of numerous glaciers, which attained a thickness of between 7,000 and 10,000 feet. Their movement was facilitated by the phenomenon known as regelation, which consists of constant momentary melting and refreezing of the ice particles, due to changes of pressure. In this way glaciers will in time remove gigantic blocks of rock and grind the surfaces over which they pass into a smooth or polished condition. Striated and ice-scratched surfaces will also result, indicating the line of the glacier's advance. Thus the rugged mountain masses and great volcanic cones of pre-Glacial times became transformed during the Great Ice Age into the rounded masses and gigantic humps which are such a familiar feature of the glaciated mountains of Britain and northern Europe, as compared with the angular ruggedness of, say, the Balkans, and the mountains of Greece, southern Italy, and Spain, all of which escaped any extensive glaciation.

As the glacier progresses, a large quantity of material, chiefly rocks, sand and clay, is collected on each side as it erodes its way; these are known as moraines, and the mass of detritus is carried along until it becomes heaped up as a vast and ever-growing deposit of débris at the lower extremity of the glacier, where it is known as the *terminal moraine*. Or it may get spread out fan-wise over a large area by the rushing streams which emerge from great glaciers, and will flood the country round.

Thus materials of strata and rocks get transported hundreds or even thousands of miles, and, while possessing a totally different character, get deposited as a compound mixture of stones, clay, sand and pebbles, in which are frequently great boulders and even fragments of fossils, such as bones, tree-trunks and mammalian teeth and tusks, collected on the way and eventually forming a heterogeneous mass, which may attain hundreds of feet in thickness, geologically known as *Boulder Clay*—the harder kinds as Till. Thus is formed the most characteristic deposit of the glaciers of Pleistocene times, proving that northern Europe was covered by a vast ice sheet, which flowed chiefly from Scandinavia and reached, when at its greatest extent, from the Urals to the Atlantic Ocean and as far south as the Harz Mountains.

Four or Two Glacial Periods? Two great Glacial periods can be traced as emanating from Scandinavia, though evidence is found for four periods in the Alpine area; these are known as the *Günz*, *Mindel*, *Riss* and *Würm* periods. Consequently, certain authorities, including Professor James Geikie, regard Europe as having been subject to four Glacial periods, but some recognise only two, the others being but minor fluctuations which did not extend to Britain or far beyond Scandinavia. The four periods are shown in the Colour folding plate facing page 128.

Günz Period. The first period, or Günz, for instance, radiating from the mountainous mass of Scandinavia over what is now the Baltic and Finland area, did not approach the British Isles, which then formed an integral part of the European continent. During a temporary recession, Iceland became severed in a general sinking of the land, of which there is evidence extending to at least 100 feet around the present Scottish coasts; then came the second, or First Great period of extensive glaciation.

Mindel Period. This, known as the Mindel, must have been one of considerable atmospheric moisture accompanied with prolonged low temperatures, which caused vast sheets of unmelted snow to descend as glacial ice from the elevated Scandinavian area over what are now the Baltic and North sea regions, where the great wall of Scandinavian ice met another lesser one descending from the Scottish Highlands, which spread over Ireland. Together this slowly travelling mass, with a thickness which ultimately reached some 5,000 to 7,000 feet over Britain and 10,000 feet over the Baltic area, spread to the traceable limits shown in the map of the Second Glacial Period.

The only part of the British Isles region to escape was that to the south of the Thames and Bristol channel, where there is evidence that an arm of the warm Western Ocean, now the Atlantic, penetrated from earlier times. Much material of the Norwegian mountains was deposited in the Boulder clay and as large erratic blocks over England; as far south as the Thames

Valley is conclusive evidence of the extent of the glaciers.

British Glaciers. In Scotland both the Grampian and Gallowegian areas had developed great glaciers which, together with those of the lesser areas of Cumberland, the Cheviots, Pennines and Wales, formed an immense ice sheet, in places estimated to reach 5,000 feet thick. This ice sheet held back and diverted the course of the Scandinavian ice. The deviation appears to have occurred in the Cleveland district of Yorkshire, which, with central and south Yorkshire, remained singularly free from ice. The ice spread out over the lowlands, while the Welsh glaciers covered Wales to the Bristol Channel. The Scottish ice poured down over most of Ireland, filling the Irish Sea area with a gigantic ice sheet, which covered even the 2,034-foot mountain of Snaefell in the Isle of Man; this glacial sheet also spread out westwards over the Hebridean area, completely covering what are now the Hebrides, and extending to the Atlantic, where it presented a wall of ice; from this great bergs floated away over the Atlantic—as they do now from Greenland. Some landed as boulders on the Scilly Islands.

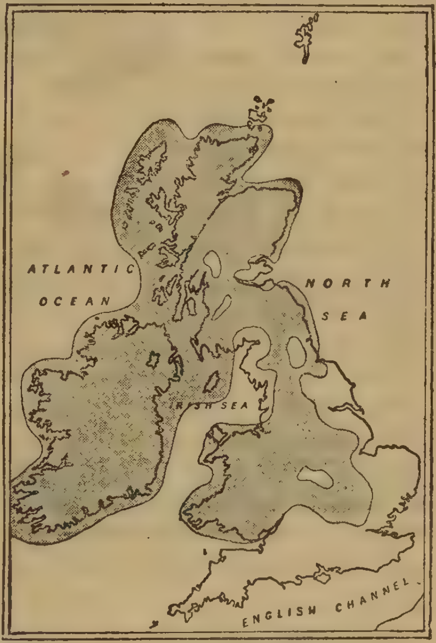
American Glaciation. In North America the glaciation was even greater than in Europe and reached a thickness of from 7,000 feet to 15,000, the glacial drift being spread out as far south as 37° of north latitude, whereas in Europe it reached only to about 50°. There are also evidences of extensive glaciation in South America, Tasmania and New Zealand, where the ice attained a thickness of 7,000 feet.

Ultimately the enormous weight of the vast ice sheet appears to have had some effect upon the earth's crust, for later on the land of north-west Europe appears to have sunk to a much lower level and eventually much warmer conditions ensued.

Interglacial Period. This middle and great Interglacial Period extended for well over 100,000 years. At first tundra, then steppe conditions prevailed and followed the retreating glaciers which left behind cold morass and all the moraine detritus which is such conclusive evidence of their one-time presence. This was followed by immense quantities of fine wind-blown dust and sand from more southern regions, which piled up into layers known as *Loess*.

This loess surface became ideal for the development of a grass steppe area such as exists over so much of Central Asia at the present time. Then great herds of animal life appeared and flourished exceedingly. The elephant, rhinoceros, sabre-toothed tiger, giant elk, wild horse and great aurochs, with numerous lesser species, roamed the plains which extended unbroken from the Severn to the Urals.

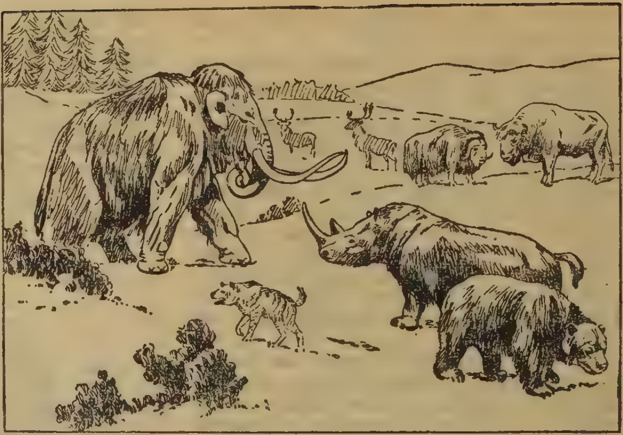
Great forests followed and spread, with bears and forest life, much of which has continued to the present time. Even the hippopotamus inhabited the great river that flowed through the plain that is now the North Sea; the Thames, Rhine and Elbe were its tributaries. Warm winds prevailed, with warm cyclones and currents from the Western Ocean, perhaps originating in the Pacific. Climatic conditions were favourable to the existence of Palaeolithic Man; he consequently began to develop and flourish, leaving increasing evidence of his presence, chiefly in the form of flint implements, in what is now southern England and central and western Europe.



BRITISH ISLES IN THE ICE AGE. *These areas of glaciation were distinct from the still vaster ice-sheets which spread from Norway over what is now the North Sea and as far south as the Thames valley.*

Then something geographical or meteorological happened, most probably one in consequence of the other, and the Highlands of Scotland, together with those of Scandinavia in a much greater degree, became covered with repeated snow-falls beyond the capacity of the summer sun to melt fast enough and then another vast ice-sheet formed, increased and spread to the extent shown in the map of the Third Glacial Period.

Riss Glacial Period. This, known as the Riss, was not so extensive as the previous visitation, leaving central and southern England untouched. Consequently Palaeolithic Man continued to develop in this region, and in France and southern Germany, and to leave much evidence of his presence and handiwork, which would otherwise have been swept away by glacial action.

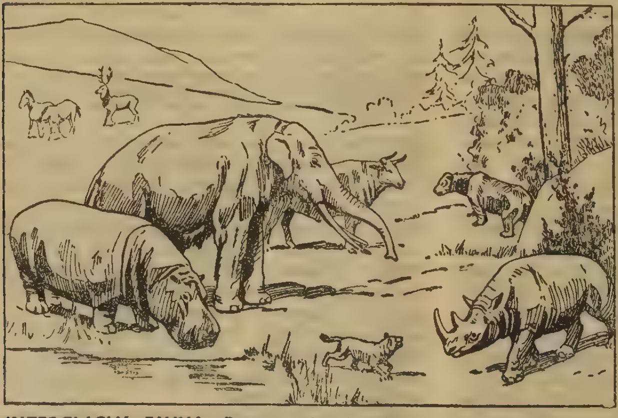


IN GLACIAL TIMES. With the spread of the glaciers over Europe a group of animals specialized to withstand the cold replaced the warmth-loving fauna; such were mammoth, woolly rhinoceros, cave-bear, bison and others. Primitive man, in the form of hunters of Mousterian culture, also appeared in later Glacial times.

Conditions were, however, very cold and man had to share his somewhat precarious conditions with great animals well protected from the inclement weather. This we know from the remains of the hairy mammoth, woolly rhinoceros, bears, reindeer, musk ox and numerous other species, found associated with man's weapons of offence and defence.

Forests were plentiful beyond the glacial limit, but obviously husbandry and agriculture were impossible with such animal life in possession. So caves, forests and river terraces sheltered man until the retreat of this great Riss period of glaciation. It was the last to visit western Europe or to extend far from the Scandinavian-Baltic area where succeeding oscillations of glacial intensity continued. The chief of these are known as the Würm and the Bühl.

Würm Glacial Period. The last of these glacial periods, known as the Würm, is variously estimated to have terminated in this country from 50,000 to 10,000 years ago, although parts of Europe may still be regarded as in the retreating stage which followed the temporary Bühl advance. The cause of these glacial periods is still a matter of investigation and speculation. That a change in the elevation of the land may have caused them is one theory. Another theory is that a geographical change, such as a temporary partition of North from South America, creating a diversion of the warm Atlantic Drift current to some other course, may have been



INTERGLACIAL FAUNA. Between the glacial crises there were intervals when the climate relented and a different fauna appeared. The early type of true elephant, rhinoceros, hippopotamus, aurochs, bears, wolves, horses and red deer characterized the long second Interglacial Period. Men of the Chellean and Acheulean cultures also flourished.

the cause. Variations in the solar heat or the passage of the solar system through a region of extra low temperature have also been adduced as explanations, but a change of tilt of the earth's axis seems a possible explanatory theory, although there is yet another favoured at present—that the Glacial periods were due to recurring meteorological changes which in some manner produced different areas of high and low barometric pressure, such as would result from, say, the warm cyclones of our latitudes taking a more southerly course and permitting the east and Arctic winds to supplant them.

Or, take for example Greenland, which is now a vast glacier-covered area in a similar latitude to that of Scandinavia, which at present enjoys a comparatively mild climate, due to the prevailing warm westerly winds and sea-currents. But if, from some geographical cause, these winds were deflected and replaced by Arctic currents and winds similar to those prevailing in the Greenland area, we may assume a resumption of the glaciation of the past, and on a great scale in north-west Europe.

Animals of the Ice Ages. The fauna and flora of northern Europe, including Britain, which was then an integral part of the Continent, assumed an Arctic character over the areas preceding the advancing glaciers. Thus we find, for example, in the eastern counties, beds containing Arctic shells and fossil remains of the Arctic birch and willow, with remains of Arctic animals. Northern and central Europe as far south as the Alps and Pyrenees was inhabited by swarms of reindeer, *Cervus tarandus*; the Arctic fox, *Canis lagopus*; the great mammoth, *Elephas primigenius*; the woolly rhinoceros, *Rhinoceros tichorhinus*; together with the bison and hyaena, the great elk or deer (*Cervus giganteus*), the cave-bear, *Ursus spelaeus*, and species of musk-sheep, glutton, wolf, musk-ox and wild boar. Remains of most of these are found in the deposits of the river-valleys of England, notably the Thames.

Among the evidences of the inter-glacial periods are beds in which are found relics of quite a different fauna, one suited to a warm temperate climate. In these beds the above species give place to the elephant, hippopotamus, hyaena, leopard, porcupine, African lynx, aurochs and wild horses—present-day types of warmer climes which again are superseded by creatures adapted to colder conditions.

Most remarkable of all is the development of the human species during the Quaternary era, the evidences left of their handiwork constituting so distinctive a feature that this era is usually designated the Age of Man, though he had acquired some of his human attributes in Pliocene times.

LESSON 20

Geology of the Holocene, or Present Age

The Holocene deposits belong to the age in which we live, an age sometimes called the Post-Glacial period. These deposits are almost entirely alluvial, peaty and loess. The alluvial are usually a continuation of the Pleistocene sands and mud, brought down by the streams and deposited along the banks of rivers in the shape of terraces. They also form the beds of rivers, and spread out great deltas at their mouths, such as those of the Nile, Danube, Ganges, Euphrates, Mississippi and Amazon. The growth of the deltaic deposits at the mouths of the Nile and Euphrates within the last four to five thousand years can be measured by the distance of the seaports of antiquity from the present-day coastline.

The peaty deposits include forest débris. These are very extensive, covering wide areas in northern and central Europe and North America, and are the remains of the vast forests which grew on the rich soil left behind by the retreating glaciers after the close of the last Ice Age. The loess deposits cover very extensive areas, chiefly in Asia, which are now steppe, prairie and tundra. In these areas the fine wind-blown sand produces a state of aridity which prevents the growth of forests; great loess deposits exist in western China, reaching some 2,000 feet in thickness, and in the adobe area of North America, where they reach 3,000 feet.

Later Fossil Deposits. In all the Holocene deposits are found more or less fossilized remains of animals of the most recent or present-day species. A few of the fossilized forms have become extinct, notably the mammoth, *Elephas antiquus*, frozen carcasses of which have been found in the ice-bound rivers and tundra of Siberia, and in the superficial alluvial deposits of central Europe and England. The gigantic Irish deer, *Cervus giganteus*, is another famous creature which has become extinct in recent, probably in historical, times. Numerous fossil remains have been found in Irish peat bogs, and also in the cave-earth and superficial deposits in England, Scotland, and on the continent. The woolly rhinoceros, *Rhinoceros antiquitatis*, also persisted until recent Holocene times, and entire carcasses, covered with woolly hair, have been dug out of the frozen Siberian tundra.

As regards birds, the moas, *Dinornis*, which were exceedingly numerous in New Zealand, have vanished only within the last two or three hundred years; their remains are very plentiful in the superficial deposits of recent times. Remains are found in the marshes of Madagascar of a gigantic bird, *Aepyornis*, which reached 14 feet in height and produced eggs 30 inches in circumference. Another bird, one incapable of flight, the dodo (*Didus ineptus*), disappeared in recent times, being last seen alive about 1680; it inhabited Mauritius, Réunion and Rodriguez, and its remains are found in the peaty deposits of these islands. The solitaire, a gigantic flightless pigeon of the same family, vanished from Rodriguez about 1760. Finally, the great auk, *Alca impennis*, became extinct in the last century, the last pair known being killed in 1844.

Earth Moulding Forces of Today. Now let us turn from the geological record of the past to consider the forces that are moulding the earth's surface today, often in a manner which conflicts with Man's wishes and requirements. This conflict is seen on a small scale when a few acres of carefully tended farmland or a homestead or two vanish in a cliff fall in a single night, as happens frequently round the shores of England, particularly along the coasts of Norfolk, Suffolk, Sussex, and the Holderness coast of Yorkshire. Another aspect of the process is seen when rivers change their course, as, for instance, the Indus and the Hwang-ho. Mountains slip from time to time, destroying fields and houses, and even slipping hillsides can cause disaster, as in suburbs of Lyons in 1930 and 1932.

In addition to these catastrophic occurrences, there are *secular movements* imperceptible to the eye—movements due to silent geological forces which are ever at work, raising a sea-bed here and lowering a whole country there—processes which are evidenced by submerged forests and raised beaches respectively. The former are very numerous around the shores of England and Wales and to a lesser degree in Scotland. The wood can scarcely be regarded as fossilized, though very ancient and usually black with age and impregnation.

Submerged forests occupy a large portion of the Thames estuary, and are obviously much later than the raised river terraces of sand and gravel deposited in the Pleistocene period, in the Palaeolithic and Eolithic ages of Man. Similar forests are found off the east coast, more particularly off Lincolnshire and Durham, in the estuaries of the Humber and the Wash, beneath the fenland, and off the south coast from Hastings to Torbay. In the Bristol Channel they extend far out beneath the sea, and are well in evidence in Porlock and Caermarthen bays. Abundant remains may be seen at very low water in Cardigan Bay, off the Wirral Peninsula, the coast of Lancashire, and as far north as the Solway Firth. This fall of the land has been proceeding for some thousands of years, judging from the remains of Bronze Age men found in the uppermost layers of these submerged forests, and from the Neolithic artifacts discovered in the lower layers. How long it will continue and to what extent it is impossible to say, and the process is so slow that many generations must pass before Man is likely to see in it a large-scale menace.

BOOK LIST

'Wonders of the Earth's Crust,' H. E. Taylor (Pitman); 'Text Book of Geology,' Sir Archibald Geikie (Macmillan); 'Aids in Practical Geology,' Grenville Cole (Griffin); 'Stratigraphical Geology,' J. A. Jukes-Browne (Stanford); 'An Introduction to Stratigraphy,' L. D. Stamp (Murphy); 'An Introduction to Palaeontology,' A. Morley Davies (Murby); 'Making of the Earth,' J. W. Gregory (H.U.L.); 'Rocks and their Origins,' G. A. Cole (C.U.P.); 'Volcanoes,' J. W. Tyrrell (H.U.L.); 'Earthquakes and Mountains,' H. Jeffries (Methuen); 'Our Mobile Earth,' R. Daly (Scribner); 'Submerged Forests,' Clement Reid (C.U.P.); 'The Study of Geological Maps,' G. L. Elles (C.U.P.); 'British Regional Geology Handbooks' (H.M. Stationery Office).

PHILOSOPHY

HERE in brief compass are surveyed the great philosophical systems which must ever rank amongst the sublimest achievements of the human intellect. Further mention of the principal philosophers will be found in the Courses devoted to CLASSICAL LITERATURE (*Vol. II*), ENGLISH LITERATURE (*Vol. I*) *and* FOREIGN LITERATURES (*Vol. V*), *but it must be emphasized that a study of the original texts—some of the most important of which are given in the Book List—is essential to a proper appreciation of Philosophy.*

15 LESSONS

Lesson

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LESSON ONE

The Meaning and Mission of Philosophy

There is doubt in many people's minds as to what Philosophy is about. This doubt may be resolved at once by a formal definition, which, although it does not take us very far, does, at least, serve to indicate the scope and nature of the subject. The object of philosophy may be defined, then, as an attempt to understand the universe as a whole—not, like physics or biology, a special department of it, but the whole mass of data to which the moral intuitions of the ordinary man, the religious consciousness of the saint, the aesthetic enjoyment of the artist and the history of the human race, no less than the discoveries of the physicist and the biologist, contribute.

Considerable doubt exists as to the value of philosophy, nor can it easily be set at rest. Let us consider philosophy first in terms of its practical results. If life is an art, philosophers are not its artists, nor does a study of philosophy confer a knowledge of its technique. If life be regarded as a chess problem, philosophy does not provide a ready-made solution; while in so far as philosophers have claimed that the study of their works fitted the student for the business of life, the claim is largely unfounded.

That a knowledge of philosophy does not directly affect the business of living, an observation of philosophers will readily prove. The political philosopher is not noticeably better either as a citizen or as a statesman than his neighbours. The metaphysician cannot provide an agreed and demonstrably correct answer to our questions as to how the universe started, whether it works mechanically, whether there is a God, or whether there is such a thing as matter. The morals of the ethical philosopher are not markedly superior to those of the plain man. In particular, he is not necessarily remarkable for what is known as the 'philosophic temperament.' He is no more serene than the man in the street, being just as likely to betray ill-temper when he breaks a shoe-lace or to swear when he misses his train.

A knowledge of all the ethical systems that have been propounded since Man began to moralize will not make the philosopher a good man, and thinking will certainly not make him a happy one. It is even possible that happiness and knowledge may be in some ways incompatible, so that we are still today faced with the choice which the Greeks propounded long ago, between being a happy pig or an unhappy Socrates. This fact need not, however, cause distress, since the question whether happiness is the only desirable thing is itself a philosophical question.

Philosophy and Science. Or consider the theoretical achievements of philosophy contrasted, for example, with those of science. Science shows a steady march of ordered progress, in which each scientist builds continuously upon the foundations laid by his predecessors. As a result, science has accumulated a formidable body of knowledge, which, in countless ways, has changed the face of the world, has brightened human life and lightened human suffering. But with philosophy it is not so. Not only are the conclusions reached by different philosophies hopelessly at variance, but there seems to be no sort of agreement even as to the subjects which should be discussed. If philosophers do not know what they are looking for, how, the reader may be tempted to ask, are they to be expected to find it?—at which point he will call to mind some time-honoured gibe about a philosopher being like a blind man in a dark room looking for a black cat that isn't there.

Nevertheless philosophy is one of the most valuable, although most difficult, pursuits of the human mind, and the greatest human thinkers have devoted their lives to its pursuit. What answer, then, can it make to the charges implied in the preceding paragraphs? First, it should be emphasized—and herein lies the answer to the charge—that philosophy reaches no agreed results, that philosophy is not the accumulation of facts, but an inquiry into the *meaning* of facts. Pooling the experiences of the scientist, the saint, the artist, and the common man, it asks what must be the nature of the universe in which such experiences are possible. It is interested, in other words, not so much in the facts as in their significance. Thus it establishes principles of selection and rejection whereby some of the facts are shown to be important, while others are rejected as trivial or condemned as illusory; it assigns values, too, and assesses the universe in respect of its beauty or its goodness.

Now, this search for meaning and significance, this task of assessment and valuation, involves considerations of a highly personal character. We shall select according to what we think important; we shall group and arrange according to likenesses which we think significant; we shall assign values to what we recognize as beautiful or good. What we think important or significant or beautiful will depend very largely upon the sort of minds we possess, and not only upon our minds, but also upon our characters and temperaments. One man will detect common elements where another observes only a chaos of differences; some will recognize the hand of God in what others insist is a haphazard collection of fortuitous events. Thus, while the facts are the same for all, the conclusions which we base upon them will be different. Nor need this difference be deplored. Just as it takes all sorts of men to make a world, so does it take all sorts of minds to find the truth about the world, and philosophy is no more to be dismissed because each philosopher has a different system, than morality is to be invalidated by the fact of differing moral judgements, or religion by the innumerable variations of religious belief.

Discovery of Order. Nor, secondly, is it the case that there are no matters in regard to which philosophers are agreed. At first sight the world is a chaos of different things, and as such it undoubtedly appeared to primitive Man; but directly speculation began, the mind passed beyond the stage of regarding the world as a mere chaos, and sought for principles to order the chaos. However various the facts of nature, it very soon becomes evident that there is at least some degree of relation between them. An unsupported stone falls not once or twice only, but always. The sequence of day and night and of the seasons, the apparent movement of the sun, the growth of crops—these all display some degree of order and hints of interdependence. So unmistakable is this order that it came to be recognized long before the birth of science, the business of which is to discuss the relations between the facts of nature; so salient are these relations that the mind must recognize them directly it begins to think at all. Whatever else is uncertain, the fact of order around us cannot be gainsaid.

Seeing the Universe as a Whole. There have been many philosophers who declared that there is no external world, many who have held that, if there is an external world we can know nothing of it, while others have maintained that mind is only an accident, looking on at the matter which produces it—but never yet was there any philosophy that did not admit, to some extent at any rate, this idea of order. The order is outside us, say some thinkers; there is nothing whatever outside us and the order is within us, say others; the order only applies to some things, say the savage and the superstitious; order is universal, says the thinker—but none of them will deny the existence of order.

Now, once the mind has begun to recognize traces of order here and there, it has a way of going farther afield, in order to see how far this principle may be traced. The whole history of science is a history of the ever-widening demonstration of the existence of order, and it is the profound belief of most men of science today that order is universal. As a matter of fact, however, philosophers have not waited for, let us say, the perfecting of meteorology in order to assent to the proposition that order is universal. Those who have contributed anything at all to the history of thought have in general believed that the order which we can recognize is indicative of order everywhere.

In this way philosophy has pointed the way to science. It has not so much discovered facts for itself, as suggested hypotheses for the scientist to investigate. In a word, it has put up signposts indicating the routes along which science should proceed, and of these the first, the most important, and the one with regard to which all philosophers are agreed, is the signpost of order.

Mental Discipline. To return to our defence of philosophy, we may note in the third place that the mental discipline involved in philosophical pursuits broadens, strengthens, and refines the mind. Philosophy will take a common object and show us that we know much less about it than we expected. A chair, for example, which appears to common sense to be four wooden legs surmounted by a square wooden seat, can be shown by philosophical reflection to be an idea in the mind of God, a colony of souls, a collection of sense data, a piece of our own psychology, or a modification of the absolute. Philosophy can give very good reasons for supposing that the chair is each and all of these things; and although one cannot definitely prove which of them it is, one can at least become quite certain that it is not merely a chair.

From this point of view the value of philosophy lies largely in its uncertainty. The man who has no acquaintance with philosophy goes through life imprisoned in the prejudices, the preferences, and the habitual beliefs derived from the society in which he happens to have been born, and the period in which he lives. If he is born in a Mahomedan country, he thinks it right to have several wives; if in England, only one. If he is born in 400 B.C., he thinks the sun goes round the earth; if in A.D. 1900, he takes the contrary view. None of the views which he holds is the result of independent thought; all are the product of convictions which, having grown up without the consent of his reason, are merely the reflection of the conventions and prejudices of his age.

To such a man the world tends to become dull and obvious. Common objects provoke no questions, and unfamiliar possibilities are contemptuously rejected. Philosophy, which raises doubts about what has hitherto been taken for granted, keeps alive the sense of wonder and restores mystery to the world. By diminishing our certainty as to what is, it enormously increases the possibility of what may be. Thus it makes life more interesting, not because of the answers it provides to the questions it raises, but because, by the mere process of raising such questions, it liberates us from the dominance of the actual and sets us on the threshold of the region of emancipating thought.

Real Function of Philosophy. We are now in a position to understand the real function of philosophy, a function which philosophy can alone fulfil and which constitutes its ultimate justification. We can exhibit this function in the clearest light by drawing attention to the fundamental difference between philosophy and science. The scientist, working away in a little watertight compartment, devotes his attention to a certain section of the universe. Thus enclosed, he arrives at more or less definite conclusions without stopping to think what relation they bear to the conclusions reached by other scientists working in their watertight compartments. This is not a criticism of the scientist; cosmic correlation is not his business, but it is not to be wondered at if some of the conclusions clash. Hence arises the need of a clearing house in which the results arrived at by the various sciences can be pooled and collated, in order that, looking at them as a whole, we may be able to infer what kind of universe it is that we live in, and hazard a guess at the destiny of human life.

These pursuits are not without their practical effect upon the men who pursue them. Those who give time to the study of such impersonal questions are bound to preserve something of the same impartiality and freedom in the world of action and emotion. Since a consideration of fundamental questions shows us how little is certainly known, the philosopher is ready to grant the possibility of contrary views having as much or as little truth as his own. Thus philosophy generates an attitude of tolerance which refuses to regard the distinction between right and wrong, good and evil, truth and falsehood, as identical with that between things done and views held by oneself and the contrary actions and thoughts of others.

Finally, the fact that no agreed answer has yet been discovered to the most fundamental questions cannot but suggest to the honest thinker that all systems hitherto constructed are in some degree false. Those who have no tincture of philosophy are inclined, on all questions not susceptible of proof, to supply the place of knowledge by converting other people's conjectures into dogmas. The philosopher, on the other hand, will admit that even his so-called knowledge is conjectural, and regard fanaticism, bigotry, and dogmatism not only as an offence against manners, but as a betrayal of the truth. Thus it is for the sake of the questions themselves which philosophy studies, and of the methods with which it pursues them, rather than for any set of answers that it propounds, that philosophy is to be valued.

Through the greatness of the universe which it contemplates, the mind itself achieves greatness. It escapes from the circle of petty aims and desires which for most of us constitute the prison of everyday life, and, forgetting the nervous little clod of wants and ailments which is the self, is elevated into communion with that which is greater than the self. On the practical side this greatness of the mind generates qualities of tolerance, justice, and understanding, in the growth of which lies the chief hope for the world today.

LESSON TWO

The Ideal State of Plato

A word of warning must now be given: philosophy is exceedingly difficult. It rejoices in technical terms and hair-splitting distinctions; it employs subtle and refined arguments, and one finds it often hard to understand why just those particular questions which are discussed have been selected for discussion. Not to be lightly attempted by any, philosophy should always be eschewed by some.

It is not possible in the following brief series of Lessons to enter into all the complexities and profundities which beset the subject. The reader may, however, form a general conception of the main problems which philosophers have discussed and of the reason why they *are* problems; some of the main systems of philosophy will be introduced, together with the basic conclusions of the great philosophers.

We shall begin with a brief consideration of the Greek philosophers Plato and Aristotle, proceed to a survey of Kant's 'Theory of Knowledge,' describe and elaborate the views of philosophical Idealism, and follow with an account of the diametrically opposed theory of materialism. We shall conclude with a brief statement of some of the subjects which are being discussed by philosophers at the present time.

Plato (427–347 B.C.), pupil of Socrates, was contemporary with Aristotle (384–322 B.C.).

Dialogues of Plato. No apology is made for beginning with a consideration of the works of Plato. Plato is, from several points of view, an ideal philosopher for those who are studying the subject for the first time; and this for two reasons. In the first place, all the main philosophical problems which are discussed by subsequent philosophers are raised for the first time in Plato's works. They are raised clearly and attractively; and, apart from the fact that the solutions which Plato propounded are intrinsically quite as important as those suggested by any subsequent thinker, a study of their treatment by Plato provides one of the easiest paths into the philosophical maze.

Secondly, Plato is the greatest literary artist of all the philosophers. He writes not only with clarity but with charm, and 'The Republic' of Plato is an exceedingly attractive book, apart altogether from its great philosophical importance. Its literary grace and the power of its thought combine, in the view of many, to render it the greatest single book in the world. No apology is therefore required for following its line of thought with some degree of closeness. Before, however, we come to 'The Republic,' it is necessary to preface our treatment with a brief account of the peculiar form—the dialogue form—which Plato's philosophical works assume.

The dialogues are discussions, usually between Socrates and a few followers, on such subjects as the nature of love, temperance, or courage, or on the destiny of the human soul. They vary very considerably in point of dramatic interest. The earlier ones aim at freshness of dramatic portraiture, and attempts are made to introduce differences of characterization between the different speakers. In the latter dialogues the atmosphere of the after-dinner table is replaced by that of the lecture room, and Socrates discourses more or less uninterruptedly, the others only making occasional interpolations in order to obtain fresh light on his meaning.

There is controversy as to the closeness of the resemblance between the Socrates who appears as the chief personage in the dialogues and the Socrates of actual historical fact. About the latter we know very little, and it is at least possible that he was, as a teacher, less advanced than the leading character of the dialogues who, bearing but little relation to the original, may be conceived to have been used by Plato merely as the mouthpiece of his own views.

The course usually taken is somewhat as follows: In recounting some everyday event, somebody employs a term in common use such as 'courage,' 'good,' or 'justice.' Socrates asks him in what sense he is using the term; what, in fact, does it mean? Various suggested meanings are put forward, which Socrates has little difficulty in showing, by the dialectical methods for which he has become famous, to be unsatisfactory. Socrates is then challenged to produce his own definition of the term, and usually takes the rest of the dialogue to do it.

Discussion of 'Justice.' 'The Republic' follows these lines fairly closely, the term under discussion being 'justice,' which is used in a sense equivalent to what we might call social morality. But although the nature of justice is thus the *formal* subject of 'The Republic,' the topic does not occupy us for long, the two main themes in the dialogue being the construction of Plato's ideal State and the exposition of his Theory of Ideas. The transition to these subjects is effected in the following way.

Two of Socrates' disciples, Glaucon and Adeimantus, brushing aside the arguments used by Socrates in the first book, make a forcible statement of what subsequently came to be known as the Social Contract Theory of the origin of society. This leads to a request to Socrates to provide them with an exposition, and, if possible, with a proof, of the superiority of justice to injustice in the light of the following considerations: (1) Before society there was no law or morality, and everybody preyed upon his neighbour, injustice being natural to Man. This state of affairs proved intolerable. Men accordingly formed a contract to live in a society in which the performance of unjust conduct would be visited with penalties. As a result we are on the whole reasonably just in our conduct, but only because we are afraid of the law and public opinion. Hence, nobody is just for the sake of justice. Men behave decently merely because they desire to avoid the social consequences of being unjust. (2) Strip justice of its rewards and injustice of its penalties; then go a step farther and visit the just man with the penalties of injustice and the reputation of being unjust into the bargain, and who would wish to be just? (3) In actual fact it is true that men do prefer justice, but only because society has taken care to ensure the performance of those actions, known as socially useful actions, which benefit it, by rewarding those who do them, giving the brave man a V.C. and the entrepreneur a knighthood.

Morality is merely the name that society gives to the kind of conduct that suits it. By maxims of the 'honesty is the best policy' and 'play for your side' type, it assures the individual of public consideration and esteem, if he does what it wants and obeys its ordinances; and so we see the just man prosper, and are ourselves accordingly just. Nor is it in this life only that the just man receives his reward. Even the gods can be 'squared,' and a little judicious piety now will guarantee an eternity of bliss hereafter. Hence the appeal of religion, like that of morality, is not to Man's goodness, but to his far-sighted self-esteem. It promotes the kind of conduct which will bring men most benefit in the long run.

It is clear that Glaucon and Adeimantus are here impugning the whole structure of social and individual ethics. What, they ask, is the sanction and basis of morality? Are morals merely conventional, as they can so easily be shown to be, or do they represent any innate preference on the part of men for the good over the bad irrespective of their consequences?

Society a Natural Growth. The answer of Socrates to the problem put by Glaucon consists in pointing out that society is a natural, not an artificial, growth. There was no pre-social contract period of society, because Man, being by nature a political or social animal, is found at all times to have been living in society. Living in society, in fact, is as natural to Man as breathing. It is not fair, therefore, to represent the ordinances of society and the social morality which they embody as being things unnatural or artificial, imposed in the teeth of Man's *natural* anti-social proclivities.

If, therefore, society is a natural outgrowth of human nature, we should expect to find the principles operative in the latter operative also in the former, and, what is more, more clearly discernible in society than in the individual, since the social field is larger. Let us, then, says Socrates, first look for the principle of justice, not in the individual soul, but where it is writ large, in the State. He proceeds, therefore, to construct the best possible State, since in such a State justice will be most clearly evident. Thus the famous Republic of Plato takes its rise. There is no space here to give an adequate account even of the main features of Plato's State: they will be found in books II–V of 'The Republic,' which will amply repay careful study.

Classes in the State. Briefly, the State is, in effect, what we should call an aristocracy of wisdom and talent. The population is divided into three main classes, each with certain specific characteristics. These classes correspond to Plato's division of the soul of Man into three parts. These are the rational, the spirited, and what Plato calls the desiring, and we should call the appetitive, part. Each part has its peculiar virtue; it is the virtue of the rational part to plan, guide and control—a task in which it enlists the assistance of the spirited part—and the role of the desiring (or appetitive) part is to be in subjection to the rational.

Each aspect of the soul is represented by a particular type of individual, the type, namely, in which the aspect in question predominates. Consequently the three classes of the State are the guardian class, dominated by reason; the military or soldier class, in which the spirited element of courage, with its associated virtues of zeal and loyalty, is pre-eminent; and the mass of ordinary citizens, the workers, whose virtue consists in going about their business, in obeying the laws and in generally acquiescing in the leadership of the first class. Justice in the State, or what we should call social and political virtue, is to be found in the principle that each class knows and contentedly performs its own job without interfering with the functions or seeking to usurp the roles of the other classes. The guardians, in fact, should rule; the soldiers protect and preserve; and the workers carry on the ordinary day-to-day business of the State without meddling in politics. To produce human beings capable of the requisite political discipline is the object of Plato's system of education.

Scope of Education. Education has two main branches, music—by which Plato means what we should call the humanities—the training of the soul and mind; and gymnastics, or the training of the body. Its purpose is to mould the citizens to the principles upon which the State is founded and in accordance with which it is regulated. They must not only live in accordance with them but embrace and seek to preserve them with all the strength of a passionate loyalty. This will ensure the smooth running of the State, and exclude the possibility of the desire for change.

Interesting subsidiary features are a complete communism extending to the elimination of the private ownership of property, the holding of wives in common, and the education of children by the State. There is an official regulation of art, as a result of which only men whose work is inspired by the austere principles of the State are to be allowed to practise their art. Further features are the exclusion of lawyers; the limitation of the function of doctors to killing or curing; and the prohibition of private fortunes.

The Good Life. The principle guiding Plato's state-building is that, just as reason should be the unquestioned master in the soul, so the class which embodies the reasoning faculty should be the governing class in the State. This class receives a special education in philosophy, which Plato regards as the knowledge of reality.

As the governing class is, by all the standards that Plato's philosophy can apply, the best, so his political creed resolves itself into a plea for specialization of function in society. The best will rule, the duty of the rest being to submit themselves to the best. It is, in fact, the business of the rulers to frame regulations so that, by the mere process of obeying them, the citizens are constrained to live the good life or, rather, the best life of which they are capable.

The object of society in general is to make the good life possible for the individual; the special virtue of Plato's society lies in the fact that it ensures that this good life shall, in fact, be lived by all its citizens. If it be objected that the great mass of the citizens—all, in fact, except the guardian class—are deprived of the exercises of self-government and live, therefore, the good lives of slaves rather than of free men, Plato's answer is that they attain to so much of the good life as their nature renders possible. Different good lives are appropriate to different classes of men, and the highest good life is appropriate only to the guardian class.

The democratic principle asserts, as against Plato, that only the wearer knows where the shoe pinches; hence he who obeys the laws should on the whole be he who makes them.

LESSON THREE

Plato's Theory of Ideas

ASKED in 'The Republic' how his state can be brought into being, Socrates replies that it will be realized only when philosophers are kings. A philosopher is defined as one who knows reality. What, then, in Plato's view is reality?

Nature of Reality. The answer to this question is to be found in Plato's Theory of Ideas, one of the most famous theories in the history of philosophy. Plato was faced with two opposing positions in traditional Greek thought as to the nature of reality:

(1) That of Heracleitus, which affirmed that everything is in a state of flux, and that change alone, therefore, is real.

(2) That of Parmenides, according to which change is an illusion and reality is changeless.

The view that everything is in a state of flux is fairly familiar, and it is not necessary to give the arguments for it at length. Physical science, for instance, shows that all material things are in a constant state of change. They tend to decay and waste away. Moreover, at every moment a thing occupies a different point in time, and must, therefore, possess different temporal characteristics; for example, everything at every given moment is older than it was at the last moment; even if you repeat two exactly similar operations, the second is different or changed from the first, if only because it *is* the second, and carries the memory of the first with it. Nowhere in the material universe, nowhere in thought or consciousness, can we find anything that does not show us this continual stream or flux of change.

The arguments for the view that change is an illusion are equally strong. Parmenides' expositions were chiefly directed to proving that reality as a whole cannot change. If we consider everything that is, it is clear that it cannot become more than it is, except by the addition of something else; but, if we start with literally everything, there is nothing left that can be added to it. Similarly, everything that is can only become less than itself by reason of some part of it becoming separated from it and departing somewhere else; but once again, if you start with everything that is, there is no place whither the separated part can proceed that has not already been comprehended in the whole reality with which you started. Similar arguments can be applied to demonstrate the impossibility of the growth or diminution of any *particular* element in the universe—that is to say, of changes in the quality as opposed to the quantity of everything that is. It follows that the whole cannot change, and that any apparent change in the parts is, therefore, an illusion.

Zeno's Arrow. Greek philosophers delighted to invent paradoxes to prove the unreality of change. Of these the most famous is that of Zeno, the Eleatic philosopher. Consider, he said, any apparent example of change or motion—an arrow, let us say, in its flight. At any given moment of its flight it either is where it is, or it is where it is not; if it is where it is, it cannot be moving, since, if it were, it would not be there; and it cannot be where it is not. Therefore, at that particular moment it is not moving. Similar arguments apply to any other point or moment in the flight of the arrow; therefore at no point or moment does it move; therefore its movement as a whole is an illusion. The illustration of Achilles and the tortoise is an example of the same reasoning.

The World of Becoming. The essence of Plato's Theory of Ideas consists of a combination of the two views just considered. What Plato did in effect was to accept both conceptions, the conception of change as fundamental and the conception of change as an illusion, but to limit their application. Heracleitus' arguments were, he thought, true of the world we know by means of our senses. In this world, that is to say, it is a fact that there is nothing which is not continuously changing. Moreover, no object can be asserted to possess certain qualities with any more truth than that it can also be asserted to possess the contrary qualities. A rabbit, for example, is small to an elephant, large to an ant, i.e. it is both small and large. Tepid water seems hot to a man emerging from a blizzard, cold to one emerging from a furnace, i.e. it is both hot and cold. As Plato puts it, sensible objects, i.e. those we know by means of the senses, fluctuate between the possession of qualities and the possession of the opposite qualities. No true judgements can, therefore, be passed about them, since they do not possess any definite fixed attributes to be the objects of these judgements. Even while we are in the act of attributing a quality to a thing it is already changing in respect of that quality. Things *are* not, in short, anything at all, because they are always on the road to *becoming* something else. (The sensible world was, in fact, designated by Plato 'the world of becoming.') Therefore they cannot be quite real; therefore they cannot be the objects of certain definite knowledge, but of opinion only. Yet, as logic and mathematics show, we do have certain and definite knowledge. What, then, is it about? Plato's answer is that it is about the world of Forms or Ideas.

Nature of the Forms. The existence of a Form is indicated whenever we use the same name to denote a common quality of a number of different objects—whenever, in short, objects can be grouped together as members of a class. Salt and snow are different objects, yet both are white; hence we are required to think of a Form of whiteness, which is somehow manifested in both of them and because of their participation in which they possess the quality in virtue of which we call them both white. Similarly, institutions and actions can both be regarded as just. Hence, there is a Form of justice which bestows upon them this common quality—which causes them, as it were, to exhibit such justice as they possess.

Reasons can be given for thinking that the entities denoted by these class names, which confer qualities, such as whiteness, upon sensible objects, and such as justice upon institutions and actions, are:

(1) Not the same either as any one or as the sum total of the objects which are found to possess the quality. It is, for example, clear that to think about whiteness is a different experience from thinking about any particular white thing, or even about the sum total of all white things. The quality of whiteness is therefore not the same as any of the objects which exhibit it. Nevertheless, to think about whiteness is certainly to think about something, if only because thinking about whiteness is a different experience from thinking about blackness.

(2) Not ideas in the mind of the person thinking about them. It is fairly plain that if squareness, for example, were only an idea in the minds of human beings, the extinction of the last human being would alter the shape of a chess-board, or, rather, would result in its having no shape at all. Yet there is no reason to suppose that the extinction of a human mind involves an alteration in the shape of that which the human mind knows. All that it does involve is that the shape is no longer known. Unless one is prepared to say that all things that are known, including tables, chairs and people, are ideas in the mind of the knower (and this is, in fact, the view of some philosophers, which we shall meet when we come to consider the tenets of Idealism), there seems no reason why the shape of squareness should be supposed to go out of existence, or to cease to characterize those things which we recognize as square, merely because they cease to be known. Plato concluded, therefore, that the Forms were contained neither in the objects which exhibited them nor in the minds that knew them; they are non-mental, non-material entities which are real factors in the universe, different from individual material things and transcending them.

In geometrical conceptions there is a clue to Plato's Theory of Ideas. In a diagram we look at a particular figure, but do not speak of *this* circle or *this* triangle, but of *the* circle, *the* triangle—the figure being a representation of the abstract idea.

The Real World. For Plato these entities constitute the real world, which is composed of immaterial forms such as whiteness, justice, goodness, circularity and so forth, which are changeless, perfect, eternal. Possessing such qualities as they possess completely and changelessly, they can, unlike the changing things we know by means of the senses, be made the objects of fixed and certain knowledge; they are, in fact, the proper study of the mathematician and the philosopher.

Being the perfect specimens of the types of which sensible objects are imperfect representatives, they may be conceived as the models to which sensible objects try to approximate. Hence, the world of sense is regarded as an imperfect copy, in a changing and distorting material medium, of the world of forms. A material thing owes such qualities and, therefore, such knowability as it possesses, to the imprint of the form upon the brute material of which it consists. It follows that the world of sensible objects is semi-real, being compounded of a blend of the world of reality which Plato calls being, and of the brute material which he thinks of as not-being. 'It floats about,' to use an expression of Plato's, 'between being and not being.'

This conception is illustrated by the famous analogies of the line and the cave which appear in 'The Republic.' Plato asks us to conceive of a line divided into two and again subdivided into four parts. Briefly, the first half of the line represents the sensible world, and the second half the world of forms. These two worlds stand to one another in point of reality as the first division of the first half, that is to say, as images seen in water, stands to the second division, that is, to the sensible objects of which they are images. Controversy exists as to the objects of the first division of the second half, which are usually thought to be those which mathematics studies; the last division of the second half stands for the world of forms.

The simile of the cave in Book VII further illustrates the relation of the world of forms to the sensible world. The analogy of the sun is invoked to exemplify the fact that the relationship is twofold. The sun is not only the cause of our seeing material objects; it is the cause of their existence. Similarly the forms are the cause, not only of sensible objects being known, but of their existing.

This simile leads Plato, at the end of Book VI, to ascribe a special place to the form of the Good. It stands at the head of the hierarchy of being, giving reality to the other forms, as they do to the sensible world. There is, however, no further reference to this conception anywhere else in Plato, and it should not be pressed.

Theory of Forms. There is no space for a full discussion of Plato's Theory of Forms. It is, however, not lightly to be dismissed, however strange it may seem at first view. Three very brief illustrations of different types may serve to illustrate the sort of conception that Plato had in mind, and the reasons which led him to adopt it.

Let us suppose that a potter takes a lump of clay and moulds it into a vase. What is it that he has changed? We may provisionally divide the ball of clay into form and matter—the matter is clay, the form that of a sphere; at the end of the process the clay has the form of a vase. Now it is clear that the matter, the clay, remains constant throughout; it has not, we will suppose, either been added to, or diminished, during the transformation. The matter, therefore, has not changed. Nor has the form, because the form of a sphere cannot become the form of a vase. The form of a sphere is, as Plato says, constant and immutable; it can only be and remain itself. All we are entitled to say is that in a certain medium the form of a vase has replaced the form of a sphere; the clay, in fact, which formerly manifested the form of sphericality now manifests the form of a vase.

Modern physics has taken the hard, tangible lumps of solid matter, the atoms of the 19th century, and so whittled them away that it is exceedingly difficult to say what is left. Matter today is infinitely tenuous and elusive: it is a hump in space-time; it is positive and negative charges of electricity; it is a 'wave of probability undulating into nothingness.' Nowhere is there anything stable, solid or constant to be the basis of the modern conception of matter. We are, in fact, left with a flux which is stripped of all qualities except that of change. This modern conception of matter approximates very closely to that of the featureless medium in which Plato conceived the forms to manifest themselves. The shapes and qualities of things, he would say, are due to the manifestation in the flux of modern matter of the forms, or, to put it in more scientific terms, to the nature of the unchanging laws which the material stuff of the universe obeys, these laws being themselves immaterial forms.

Aesthetic Appreciation. In one of his most famous dialogues, 'The Symposium,' Plato applies the Theory of Ideas to the problem of aesthetic appreciation. Roughly his conclusion is that there is a form of beauty which manifests itself in great works of art, and which is the cause of the peculiarly exciting emotions that they arouse in us. The problem of aesthetics is very puzzling. If A says 'these gooseberries are sweet,' and B 'they are sour,' we recognize that both A's judgement and B's judgement may be right, since each is making a statement, not about some quality possessed by the gooseberries, but about the reactions to the gooseberries of his own palate. It is the effect produced upon him which he describes as sweet or sour respectively. One man's judgement, in other words, is as good as another's.

But in art criticism and appreciation, we feel that one man's judgement is not as good as another's; that one man can have good taste while another has bad; and, even though jazz produces feelings of pleasure in more people than does Bach, or the latest thriller than does Shakespeare, we are not, therefore, prepared to agree that jazz is better music than Bach, or the latest thriller better literature than Shakespeare. We recognize, in fact, that there is some objective standard in these matters, by reference to which the value of different works of art may be assessed, irrespective of the pleasure which they happen to give. It is precisely this objective standard that Plato's theory of a form of beauty, manifesting itself more or less fully in aesthetic objects, seeks to supply.

Subjects for Discussion

(1) Was society formed as the result of a contract (implied or expressed) made by men to live in society?

(2) Do we only obey the laws and act rightly through fear of the consequences, if we disobey them?

(3) If you could become invisible at will, would you deny yourself the satisfaction of your desires, because of moral considerations?

(4) Is the rule of the best either (a) desired, or (b) desirable, since the best are not the most and do not represent the most?

(5) What are the reasons for believing in the imperfect reality of the sensible world?

(6) What are the reasons for believing in the existence of Forms?

LESSON FOUR

The Philosophy of Aristotle

It is not proposed to describe the philosophy of Aristotle with the fullness of treatment accorded to that of Plato. This is not because Aristotle is less important as a philosopher or because his ideas have been less influential. On the contrary, throughout the Middle Ages Aristotle was the dominating influence in philosophy, and his works were regarded with the reverence appropriate to sacred writings. His ideas are, however, less capable of concise formulation than those of Plato; they are more technical, and they tend to demand some prior acquaintance with philosophy for their comprehension. One or two essential doctrines in the Aristotelian philosophy must, however, be included here, not only because of their intrinsic importance, but because of their influence on subsequent thought.

Aristotle was a pupil of Plato's, and in regard to most issues his philosophy takes its start from a criticism of the views of his predecessor. He was, in particular, critical of the doctrine of the Theory of Ideas. The mistake, he held, that Plato had made was to endow with separate existence the common qualities of individual things. Because a number of things had the common quality white, Plato had deduced that there must be a Form whiteness, over and above the white things. On the contrary, Aristotle maintained, there can be no kind of existence other than that belonging to individual things.

Aristotelian Analysis. As an alternative solution, he himself put forward the doctrine of Matter and Form, to which reference was made in the preceding Lesson. Consider, said Aristotle, any completely developed individual thing, either a natural thing such as a horse or an oak, or a manufactured thing, such as a vase or a copper bowl. Now a horse or an oak is made of the same chemical constituents as a pig or an ash, but, owing to the fact that these constituents are arranged differently, the horse or the oak has a characteristic form or structure different from that of the pig or the ash.

Aristotle held, therefore, that each individual thing can be analysed into two constituents: first, the matter of which it is composed; secondly, the law of organization or structure manifested in the matter, which accounts for its having the characteristics that it has, and for its difference from other related things. The first element he called Matter; the form of organization or structure he called Form. Everything that exists exhibits these two elements, and there is a hierarchy or grading of things according to the degree to which they embody Form. Thus an oak is composed of the Matter 'tree' and the Form 'oak'; a tree is composed of Matter 'wood' and Form 'tree'; therefore tree, which is Matter to the oak, is Form to wood; an oak, in fact, is a more differentiated individual thing than a tree.

Aristotle does not suggest that Form exists in independence of Matter; Form is merely the way in which the matter is organized. The crudest form in which matter exists, its lowest degree of organization, is in the elements; but even these are differentiated from one another by their specific and appropriate forms of earth, air, water, etc. At the other end of the scale, God, and God alone, is conceived to be all Form and no Matter.

The doctrine of Matter and Form provides an answer to the question—what are the constituents into which any particular thing may be analysed? A further and no less important question is—how does any particular thing come to be what it is? The answer to this question is provided by Aristotle's doctrine of Potentiality and Actuality. Let us suppose that we are considering two originally indistinguishable germs—the germ of an oak, let us say, and the germ of an ash. It is, we will suppose, not practically, even if it be conceivably, possible to distinguish one from the other. Nevertheless, it is a fact that one will grow into an oak and the other into an ash, and that neither has the capacity for becoming anything other than what it does in fact become.

Aristotle expresses this fact by saying that each germ is already *potentially* what in due course it will become *actually*. Thus, every growing thing possesses originally a potentiality to realize its appropriate structure or form. The process of growth is a process by which this potentiality becomes actualized. The form, to revert to the language of Aristotle's other conception, which is originally latent or potential, becomes actual.

Looking at the process from the other end, we may say that the developed product is the actuality of which the initial material contained the potentiality. The process by which a potentiality becomes actualized is not a limitless process; the realization of the appropriate form is its end. Thus every growing thing in Nature may be regarded as seeking to achieve an end, and as being drawn forward by the end which it is seeking to realize from the beginning of its development. The application of this doctrine is not confined to natural growths. If, for example, an architect proposes to build a house, the house is potential in his initial plan or idea, and the actual process of construction is merely the making actual what already existed potentially.

God and the Universe. Combining the doctrines of 'Matter and Form' and 'Potentiality and Actuality,' Aristotle believes himself to be in a position to give the first complete account of the causes of the present world order—or, in other words, the first complete answer to the question, 'What is the reason why the world contains what it does and appears as it does?' This answer is contained in the doctrine of the 'Four Causes.' If, says Aristotle, you want to know why a thing has become what it is, there are four factors to be taken into consideration. First, there is the Matter of which the thing consists—the germ from which the oak has grown. This is called the *material cause*.

Secondly, there is the Law in accordance with which it has developed. The germ, in other words, has a tendency—which it cannot escape—to grow in the manner appropriate to oaks, and not in that appropriate to ashes. This tendency or 'Law' of development is called the *formal cause*.

Thirdly, there is the agent whose initial impulse sets the whole process going. There must, in other words, be a parent oak that produced the germ which we have seen to be the material cause; the agent is called by Aristotle the *efficient cause*.

Fourthly, there is the result of the whole process—the End or actualized Form which the developing germ may be said to be seeking to realize—the oak from the acorn, or the completed picture from the artist's inspiration. This is called the *final cause*. The Greek word for final cause is 'telos,' and all doctrines which, like Aristotle's, emphasize the end or purpose which a developing thing may be seeking to realize as a determining factor and motive force in its growth are called teleological doctrines.

Mechanism and Teleology. It is important to distinguish the teleological causation, as it is called, from mechanistic causation. The latter insists that a thing is determined and caused from behind—in other words, that a complete account of its present nature could be given in terms of the factors from which it has derived, and that a knowledge of these factors would enable us to predict it. This is the kind of causation appropriate to the workings of a machine, every movement of which is completely determined by the totality of factors constituting its preceding state.

Teleological causation insists that, in addition to these factors, account must be taken of that which the thing is trying to become. We can think, for example, of his conception of the end of the race as determining the movements of the runner who seeks to win it; of his idea of the completed picture as prompting the efforts of the artist who seeks to paint it. The nature of a thing, we shall say, is not realized until it reaches its final or completed condition; and we may further conceive of every growing and developing thing as animated by a desire fully to realize its nature. In this sense the nature of a thing may be regarded as a goal, already pre-formed, inspiring and determining the process of a thing's development towards the goal. While not ignoring the part played by mechanistic causation, the whole tendency of Aristotle's philosophy is to emphasize the teleological aspect of growth. His philosophy is essentially purposive; it describes things in terms of the end they are seeking to evolve.

Conception of God. This tendency is exemplified by Aristotle's conception of the Deity.

The question may be asked: 'How and why does the process of development described by the doctrine of Potentiality and Actuality take place? What is the initial motive force of the whole process?' Aristotle's answer is—the desire of the world for God. God is conceived neither as creative nor as supervisory. He is not responsible for the world, nor does He interfere with it. He is perfect, aloof, and detached, dimly sensed by the world, and, because of His perfection, loved as well as sensed. Just as the particular good I desire and conceive moves my desire and determines my efforts to secure it, so God moves the desire of the world and determines its development towards Him. He is conceived as a magnet, drawing the world; and the motion which the world's desire for Him engenders is the cause of the whole cosmic process whereby Form develops in Matter from Potentiality to Actuality.

Aristotle and Christian Theology. Aristotle's conception of God was ultimately worked into the structure of Christian theology. Admittedly, it is a far cry from a God untroubled by the affairs of a world to which He is related only as the remote object of its aspiration, to the Christian God Who is concerned with the welfare of sparrows and the lilies of the field. Nevertheless, the Scholastic philosophers of the Middle Ages effected a fusion of the two conceptions.

For example, Aristotle's God is not creative; nevertheless, it is the desire of the world for Him which is the cause of the world process of growth and development. This process, as we have seen, consists in the continual actualization of Forms which were previously latent or potential. Hence, it is due to the influence of God, even though He does not consciously exercise any influence, that things develop as they do and become what they are.

In this sense, then, the world is dependent upon God for being what it is, and God may, therefore, be regarded as, to this extent and in this sense, creative. By a number of subtly ingenious arguments, Aristotle's theism was fitted into the theology of early Christianity, and, for the Scholastic philosophers, Aristotle became a kind of second Bible.

Problem of Pain and Evil. Apart from the uses to which it was put by early Christian philosophers, Aristotle's conception of the Deity has certain obvious advantages. The great—indeed, the insoluble—problem of the ordinary theological conception of a creative God is the problem of pain and evil. If God existed before the world, and if God is all good, there was initially neither pain nor evil. God, therefore, either willed them to come into existence, or He did not. If He did, He is not benevolent; if not, they exist in His despite and He is not omnipotent.

If it be said that pain and evil are willed not by God but by Man, upon whom God has had the goodness to bestow the gift of Free Will, we are faced by the problem raised by the fact of God's omniscience. God, if omniscient, must have known the use which Man would make of his Free Will to do evil and to inflict pain. He must have known, therefore, that the gift of Free Will to men would result in the introduction of pain and evil into a world which knew them not. The concept of Man's Free Will, therefore, does not enable God to evade the responsibility for the pain and evil of the world.

There are various ways of meeting these difficulties, but in the opinion of many none is satisfactory, the problem of pain and evil being frankly regarded by many theologians as a mystery which Man cannot, in the present state of his knowledge, aspire to solve. Aristotle's conception of the Deity does not involve this problem, since, as Aristotle's God did not create the world, He is not responsible for its imperfections. God, for Aristotle, is the changeless source of value, perfect and aloof, not contaminated by interest in or responsibility for the imperfect and the changing.

The following topics in this and the immediately preceding Lessons may be considered:

Do the Forms of objects exist independently of things, or are they in some sense bound up with them? If so, what is their relation to the Matter in which they appear? Can a thing be determined both mechanistically and teleologically?

LESSON FIVE

Medieval Philosophy

It is not unusual for an age to belittle its predecessor. True to type, the scholars, architects and fashionable society of the Renaissance belittled as uncouth the 'Gothic' styles and philosophies of the 'Middle Age'; these terms in themselves convey ridicule and are misnomers, for the 13th century craftsmen have little in common with the barbarian invaders of the Dark Ages and the term 'Middle Age' was never used by writers of that time. From Rabelais down to Locke, and even into the 18th century, the medievalists were decried as musty obscurantists who did not understand 'nature' and only filled a gap between the world of Greece and Rome and that of the Classical Revival in the late 15th and early 16th centuries.

Only when the new age had besmirched nature with the hideous factories and industrial conditions and with the bitter national and religious wars which sprang from modern ideas and inventions, did Horace Walpole strive after the Gothic in Straw-berry Hill, while Goethe had a vision of the Middle Age in the stone and 'Stimmung' of Strasbourg Cathedral.

In the Middle Age the philosopher was almost inevitably a priest, for the priests were the schoolmasters and their calling provided the only way to learning, except for the rich or particularly lucky men. Hence the medieval philosophers are often spoken of as schoolmen and their philosophy as scholasticism.

Augustine (354–430). This saint was Bishop of Hippo in North Africa, and had nothing to do with his namesake, the first archbishop of Canterbury in England. Augustine of Hippo is important as one who handed on to the Middle Ages what remained of the knowledge of Greek philosophy—it was little because the barbarians had done their destroying thoroughly. As the Middle Ages did not start until some five hundred years after Augustine's death, and during these intervening years he had no worthy disciple, the legacy was inconsiderable. However, Augustine passed on various theories, mostly of a neo-Platonic origin, and a philosophy, mixed with religion, which sought 'to see the truth of contingent beings in the Divine light.' He believed that truth impressed itself on mankind like a seal which leaves its imprint in the wax. In this way Augustine came to find the world beautiful, clothed with goodness and light. His doctrines, especially on the nature of God and the Spirituality of the Soul, had great effect on the scholastics to come. In theology, he reaffirmed and developed St. Paul's teachings, and his influence on the theology of the West is second only to St. Paul's in importance.

John the Scot. Born in Ireland some time during the 9th century, Johannes Scotus Erigina, as he is sometimes called, lived on the eve of the Middle Ages and of that Scholastic Philosophy for which he is considerably responsible.

Though never conquered by Rome, Ireland had connexions with the classical world, particularly after the foundation of the Church by St. Patrick. The Irish were great travellers: they spread the faith far and wide, especially along the Rhine and on both sides of Lake Constance (where they founded monasteries on Reichenau and at St. Gall); they had missions, too, at Bobbio in the north of Italy. Thus foreign students came to make the long journey to Ireland—there are the graves of 'Seven Romans' on Aran in the Far West—to study in a pleasant country at numerous monasteries where born teachers were abundant. Cashel, Clonmacnoise and Monasterboice, remain, though, in ruins, to tell us how far ahead of Western Europe Ireland was in art and learning at this time.

So it was not unusual that John the Scot knew Greek: he inherited his Greek philosophy from both pagan and Christian sources. Probably he is more akin to the 5th century than to medieval times in thought, but his lively power of expression made a deep impression on the early schoolmen. In his theories about the essence of God, he is largely neo-Platonic; from Plato, too, comes his theory that God's will and intellect are an indivisible substance identical with goodness.

However, John is fervently Christian. He saw in man's return to God a transfiguration whose value far exceeded any suppression of individuality. To him, the soul spiritualized the body, which, however, remained body, as air remains air when illuminated by light and molten metal is still metal after passing through the fire.

As all humanity returns to God, there is no place for Hell in John's conception. For this and for his general 'newness,' he was rejected by the Church. The schoolmen decided that neo-Platonism was insufficient and turned for a Christian solution of their problems to the more realistic philosophy of Aristotle.

Influence of Arabian and Jewish Philosophers. Not Christian, the Arabs of the 12th century were more cultured than the Crusaders, whom they regarded generally as heavy northern heretics. The Saracens had better table manners, were more skilled in architecture, astrology and mathematics, and knew much more about Greek philosophy than their contemporaries in Western Europe. As a result of the Crusades, especially after the loss of Egypt and Spain, the Christian World made no conquests but learnt the value of damask (Damascus), satin (Zaitun), steel from Moorish Toledo and leather from Moorish Cordova, and it brought back a new knowledge of medicine, algebra and Aristotle. For the Arabs had learnt Greek philosophy from looted manuscripts and Christian slaves. Also, they had knowledge from native sources; a school of philosophy through which the teachings of both Aristotle and Hippocrates spread had been founded at Edessa in the 4th century. For centuries, too, the Arabs were more or less friendly neighbours of the Eastern Empire before they went to war and conquered it.

Of the Arabs, Ibn Roshd (1126–98) of Cordova, usually known as Averroes, is probably the most important. He was a notable commentator—Dante praised him as such—whose mysticism drew a great deal from Plato and something from the Hindu idea of Nirvana and from the Persian religion. Averroes saw in God the source of all Intelligences, of which human intellect is the last and purest. The mystical union of the soul with God he regarded as the end of life.

Judaism also played its part. Greek influence was considerable in Palestine at the time of Christ; later it increased. When the Moors conquered Spain, they tolerated the Jews: Jewish philosophers, scientists and literary men flourished. Of the philosophers, Avencebrol (1050) and Maimonides (1135–1204) are the most important. The latter attempted to give a philosophical justification, on an Aristotelian basis, to Jewish doctrines. Hence his importance in the advent of scholasticism. So paradoxically, as it were, Aristotle and realism came through the paynim Arabs as balm in an age when thought in Western Europe was largely theological and entirely Christian.

13th Century. During this period Europe gained peace and prosperity, largely from a development in centralization and unity at the expense of regionalist and separatist elements. It is, of course, quite erroneous to look on the Middle Ages as a period of bellicose anarchy. At no other time has Western Europe been more united and peaceful, for we must regard baronial squabbles as the rough sport of a rougher age. Except for the Crusades and the Spanish struggles to eject the Moors, which were religious wars between Europeans and foreigners, the continent was free from national wars until the English invasion of France; by that time the period of the Middle Ages, properly so called, was drawing to a close. Pope and Emperor had some pretensions to control the destinies of Western Christendom—at any rate, outside the turbulent British Isles.

It has already been shown, early in this Lesson, that the Crusades brought into Europe new learning and commodities from the East. The capture of Constantinople by the Crusaders in 1204 delivered enormous spoil to Venice. Not the Turks, it is interesting to note, were the losers but the Greek Emperors whom the Crusades had set out to aid. The city of the lagoons was henceforward the main link between Orient and West. Plagues were few, life grew more comfortable and the monastic schools ripened with age. Universities grew and provided scholars. In them were generally the new mendicant orders of friars, most of them eager and even good teachers. Finally, Greek books from Constantinople helped to introduce that knowledge of Greek philosophy which was already being gleaned from Arab and Jewish sources. The age of scholasticism was at hand.

Albertus Magnus (*c.* 1205–80). Probably due credit is not always given to this philosopher's genius, paradoxically enough because he was the teacher of Aquinas. But though the pupil was undoubtedly more brilliant than his master, to Albertus must be given the praise due to a great teacher whose influence was tremendous at the universities of Cologne and Paris—centres the one of Rhenish, the other of French, and, through France, of English, thought. Albertus was teaching and writing for forty years. His influence as a pioneer of scholasticism should not be underestimated, though he lacked system and tended to confuse the teachings of Aristotle with those of neo-Platonism.

St. Thomas Aquinas. The most brilliant of scholastic philosophers was born about 1227 of a Neapolitan noble house, educated at the rich and aristocratic monastery of Monte Cassino, near Naples, and had the Emperor as cousin. He chose to join the Dominican Order of friars, with their tradition of poverty and active thinking and teaching. When his family kidnapped him, he refused to change his ways and roughly handled an 'Eve' they sent to tempt him from his ways. Finally, he escaped from confinement and went to Cologne to study under Albertus Magnus, whom he followed to the University of Paris. His fame was already established when he began to work for his doctorate at the age of twenty-five. It grew when, with his friend the Franciscan St. Bonaventura, he successfully justified the friars against the secular clergy before a papal court. In 1263 he paid a short visit to London, to attend a general chapter of his order; he probably lodged near the site of 'The Times' office. He spent the latter part of his life (he died in 1274) in Italy, where he compiled the *Summa Theologica*, a compendium of all human knowledge with regard to religion.

At the outset of a study of the most 'subtle' of scholastic philosophies, one point in particular should be grasped. The great Greek philosophers, like most intelligent Greeks of the 5th century B.C., had little serious regard for the gods of

Olympus, deities of a far more primitive age who ruled only in the hearts of ignorant countryfolk and as popular 'stooges' for the salacious witticisms of poets. Plato and Aristotle envisaged a source of goodness and wisdom, but they had not the Christian idea of a creative God 'revealed' to mankind.

Thirteenth century Europe, on the other hand, was permeated with a deep sense of Christian faith, coming from a Church whose influence spread over all branches of learning, professional knowledge and administration, and was the unique source of religion. So it is only natural that St. Thomas Aquinas should stress the importance of theology, while not diminishing that of philosophy, which is the handmaid but not the slave of the former. His Aristotelianism is visible in his recognition of the intellectual appreciation of God; to him, the intellect discovers God and prompts Man's will to follow it to knowledge, which is his gate to wisdom. But, partly no doubt to meet the views and objections of non-Christians, Aquinas stresses the superiority of faith to reason—a trend all the more important because his own genius lay precisely in a lucid and rationalist presentation, worthy of a brilliant, legal mind.

St. Thomas envisaged reason and faith as having for their end a knowledge of God and his wisdom; but reason starts from 'sense data,' while faith rests on revelation and authority. Each needs to study the knowledge arrived at by the other. This cannot damage either of them, for they cannot be contradictory, since both reason and faith come from God, the one and absolute source of truth. Aquinas found faith the more important of the two, since it bestows a reason which Man could not otherwise possess; here, revelation becomes important, as understood by Christian, but scarcely by pre-Christian, philosophers.

Aquinas and Aristotle. Aristotelianism suited St. Thomas's theory because his teachings were more scientific and rational than those of Plato, whose 'World of Ideas and God' had suited the early Christian mystics. There was, too, a freedom in Aristotle from the dangers of pantheism, which had tainted the neo-Platonists and a good deal of Levantine thought in the two centuries after Christ. It should always be remembered that Christianity started at a meeting-place between East and West, that Greek rather than Latin was the medium of intellectual thought in Palestine and Syria, and at Alexandria, where were the greatest library and university in the world. Pantheism and dualism were dangers to be still watched and scotched in the time of Aquinas.

St. Thomas's systematic methods were all the more successful because combined with simplicity of expression. Professor de Wolff ('History of Mediaeval Philosophy') compares the scholasticism of Aquinas with the 'cathedrals of the beginning of the thirteenth century, which also strive to attain power in logic and soberness.' And if Aristotelianism, blended to suit the Christian palate, was the basis of Aquinas' philosophy, he gained much of his knowledge of Aristotle through St. Augustine and the Arabs. From Augustine, Plato, and, above all, from Christ, came his idealist inspirations. Finally, to the genius of St. Thomas himself is due that brilliant synthesis which swept through the universities of Paris and Oxford, universities organized on a regional basis and representative of the best thought not from one city but from all over the country.

Duns Scotus. Like John the Scot, Duns Scotus has no recorded birthplace; also the year of his birth is uncertain (*c.* 1265). But it seems likely that he was born at the little town of Duns, between Edinburgh and the Border, and died in 1308. He was a Franciscan, one of a more radical and emotional order than the Dominicans to which Aquinas and Albertus Magnus belonged. As a native of this country and a lecturer at Oxford, his importance in English intellectual thought at the time was considerable—particularly, as has already been said, since to Oxford came young men not only from the neighbourhood but from all parts of Britain and even from the Continent. Scotus earned the title of subtle: he was anything but a dunce, though over-elaborate Scotists a century later may have deserved the tag for their often ridiculous preciosities.

In many ways Scotus is like Aquinas, more so than his differences with the latter might lead us to imagine. Both men were friars; in the Catholic Church, this fact means that they have much in common, especially if set against their successors, the very different philosophers of the 19th century. It often seems as though Scotus was attempting to score points by his elaborate exploitation of any breach he could make in the defences of Thomism.

Aquinas had been perhaps too much of an intellectualist; that is to say, he did not allow enough scope for will to suit the Voluntarist theories of the Scotists. From the promise that humanity will recognize the infinity of God, Duns Scotus goes on to suggest that God's will is the ultimate test of virtue. The Christian God, unlike the Hellenistic deity, is not only the storehouse but the source of ideas; not only is He goodness but its source. There is no limit, then, to God's will, though He will avoid contradictions and preserve unchanged laws once decreed. The Scotists thus became great protagonists of the universality of being—real distinctions between essence and existence disappear, as they do between the soul and its faculties; all divine attributes are fundamentally one.

Yet, because Scotus is the champion of will, he becomes also that of the individual. This is perhaps one reason for the popularity of his voluntarism, in preference to the intellectualism of Aquinas. It would not be fair to suggest that Aquinas would have disagreed with his rival's theory, but Duns Scotus did lay more stress on the individual and considered that his originality would exist even when he achieved final perfection.

Duns Scotus has had a not inconsiderable following in the Catholic Church, but his influence upon philosophy can scarcely be compared with that of Aquinas.

William of Occam. The spirit of destructive criticism, which has been remarked already in Duns Scotus, grew more marked in the 14th century. The pure constructive work of the 13th century was over; in its place were found over-elaborate Decorated architecture and precious wrangling on philosophical trivialities. Undergraduate Oxford was already prone to problems for problems' sake, and Occam (*c.* 1295–1349) was a typically 'clever' young don.

The scholastics had been mainly inductive in their method. Scientific discoveries were to lead to deduction. Oxford's interest in science had developed immensely since the versatile Roger Bacon. So it came about that Occam applied mathematical methods to problems of theology and philosophy. He taught that the only substances are individual things and their properties: the universal exists only in the soul (thought) of the Unacknowledgeable person. More thoroughly than Scotus, Occam applied moral laws to the pure and simple will of God. Like Descartes later, Occam might have said that had God wished, He could have made it meritorious for Man to hate Him. Scotus had put a restriction on any change in the first two commandments: Professor Gilson ('Philosophy in the Middle Ages') suggests that, according to Occam, adultery and theft could be considered virtues if God so willed, and that He only recompenses virtue and punishes vice because He so wishes. Once the universal archetypes and essence are removed, there is no barrier to arbitrary divine power. Gone was the middle way between faith and reason which Duns Scotus had counselled. Nominalism had returned and the first triumphs of pristine science had appeared in the 14th century, 'in the very womb of the philosophical school of which William of Occam is the chief representative' (Gilson).

Indeed, even though Occam stresses the omnipotence of the divine will, he seems to throw doubt on any proof of the existence of God and His attributes. Championing the Empire against the Papacy, he concludes his work of ill-reasoned destruction by helping politically, as well as through his writings, to bring down the fabric of scholasticism. New discoveries of scientists, printing and gunpowder, together with the rebirth of classicism, were soon to bring the Middle Ages to an end.

LESSON SIX

Descartes, Spinoza and Leibnitz

THE philosophical significance of the word Rationalism is very different from its use in ordinary language. Philosophical Rationalists are those who believe that truth about the universe can be arrived at by the exercise of reasoning without reference to observation. If the facts observed, e.g. by scientists, conflict with the conclusions at which reasoning has arrived, they tend to be dismissed as illusory or at best as semi-real. Hence Rationalism, which normally issues in some kind of Idealist philosophy, tends to make a distinction between appearance and reality, 'appearance' being the world as it appears to our senses, 'reality' being the world as revealed to the reasoning faculty employed in philosophical speculation and analysis.

Since the reality arrived at by the reasoning faculty of philosophers is more ordered, more unified, and more satisfying emotionally than the world of which our senses make us aware, and has usually included, and sometimes been identified with, a deity spiritually conceived, Rationalism in philosophy tends to issue in beliefs which are diametrically opposed to those commonly advocated by the rationalists and secularists engaged in anti-religious propaganda.

A Priori Knowledge. The belief that the nature of the universe can be discovered by reasoning, independently of observation, rests upon and presupposes the existence of knowledge which we possess initially, or have somehow acquired otherwise than through our senses. Such knowledge is called *a priori.*

Let us consider, for example, the case of inference. The knowledge involved in the making of inferences—as, for example, when, having seen a man enter a room containing one door and no window, and, having carefully watched the door and failed to observe him coming out, we infer that, *therefore,* he is still in the room—appears to be *a priori.* Inferential knowledge is incapable of being proved, because the validity of inference would have to be assumed in any process of proof we proposed to undertake. All reasoning processes —e.g. whenever we say that one thing follows from another—involve inference, and to deny inference is, therefore, to deny the validity of reasoning. Yet it is only by reasoning that the validity of inference could be established. If, then, the validity of inference cannot be proved, the fact that we not only infer but infer correctly seems to show that our knowledge of inference is given *a priori.*

To take another example, we come to know in the first place that two and two make four by taking instances of pairs of objects, putting them together, counting them, and finding that they make four objects. We then realize that the truth we have discovered applies not only to the objects we have counted, but to other objects that we have not; that the truth that two and two make four holds, in fact, universally of all objects, and would remain a truth even if there were no objects to count. Since we know that this truth is true in respect of objects not experienced by us, it follows that our knowledge of the truth cannot be derived entirely from experience. Experience was, no doubt, necessary in the first instance to draw our attention to the truth; but, once noticed, the truth was seen to be independent of the experience which illustrated it. Hence, though all our knowledge may begin with experience, it does not all spring from it. It is this knowledge which does not spring from experience that is called *a priori.*

Descartes' Method of Doubt. If, then, there is *a priori* knowledge, as the Rationalists have maintained, it will follow that we know many things that we shall be unable to prove. That they are self-evident to the intellect will be a sufficient guarantee of their truth. Hence, Descartes (1596–1650), the father of modern philosophy, lays down the axiom that whatever the intellect clearly and distinctly conceives is true. Setting himself to doubt whatever could be doubted, he finally arrived at one fact which, it seemed to him, was indubitable; this was the fact that he was doubting. To doubt is to think, and to think implies that one is a self-conscious, reflective being. Hence, Descartes arrives at the proposition which is the basis of his philosophy: 'I think, therefore I am.'

This proposition carries with it two important consequences: (1) There is an ego, or I, who doubts; hence there is an ego, or I, who is conscious. The ego who is conscious at one moment is the same as the ego who is conscious at the next. Hence, there is a continuing self which is other than the psychological states which occur in and to it, and which joins these states together, much as beads are threaded on a string. The conclusion leads to the belief in a self which does not passively receive experience, but is active and to some extent determines what experiences it shall have. (2) The mind knows its own states with more readiness and certainty than it knows the objects of its states—the emotion felt at seeing a ghost, more certainly than the ghost. This suggestion rapidly leads to the conclusion that the mind knows only its mental states.

The Mind-Body Problem. Descartes, without himself drawing this conclusion, was led to maintain a sharp distinction between mind and what was not mind. He conceived the world, in other words, as a dualism of mind and matter, and the human being as a dualism of mind and body. The problem of the relation of mind and body which is thus raised by Descartes is one of the most difficult in philosophy. It is also the fundamental problem of psychology. Briefly, the problem may be stated as follows: Mind and body are continually interacting in an infinite number of ways—indeed, they influence each other at every moment of our waking life. If I am drunk, I see two lamp-posts instead of one; if I fail to digest my supper, I have a nightmare and see blue devils; if I smoke opium or inhale nitrous oxide gas, I shall see rosy-coloured visions and pass into a state of beatitude. These are instances of the influence of the body upon the mind. If I see a ghost, my hair will stand on end; if I am moved to anger, my face will become red; if I receive a sudden shock, I shall go pale. These are instances of the influence of the mind upon the body.

The examples just quoted are only extreme and rather obvious cases of what is going on all the time. Many thinkers, indeed, assert that mind and body are so intimately associated that there can be no event in the one which does not produce some corresponding event in the other, although the corresponding event—which we may call the effect of the first event—may be too small to be noticed. The interaction between mind and body is, at any rate, a fact beyond dispute. Yet when we come to reflect upon the manner of this interaction, it is exceedingly difficult to see how it can occur. Mind, it is clear, must be something which is immaterial; if it were material, it would be part of the body. The contents of, or the events which happen in the mind—that is to say, wishes, desires, thoughts, aspirations, hopes, and acts of will—are also immaterial. The body, on the other hand, is matter, and possesses the usual qualities of matter—shape, size, weight, density, inertia, occupancy of space, etc.

Now, there is no difficulty in understanding how one material thing can be influenced by another. Each possesses the same attributes of size, shape, and weight, in virtue of which each can, as it were, communicate with or get at the other. Thus, a paving-stone can crush an egg because the egg belongs to the same order of being as the stone. But how can the paving-stone crush a wish, or be affected by a thought? Material force and mass have no power over ideas; ideas do not exert force, nor do they yield to mass. How, in short, can that which has neither size, weight, nor shape, which cannot be seen, heard, or touched, and which does not occupy space, come into contact with that which has these properties?

Thus, what has to be reconciled is the fact of apparent continuous mind-body interaction with the apparent impossibility of understanding how such interaction could possibly take place.

Spinoza. Born in 1632 at Amsterdam to a family of exiled Portuguese Jews, Spinoza had from early days an outlook born of widely different traditions. His parents were crypto-Jews, that is to say, Jews whom the Inquisition had compelled to become Christian, though they somewhat naturally remained largely Hebrew in outlook and, in this case, had reverted to their old religion on arrival in Holland. This curious religious background accounts partly for Spinoza's subtle understanding of both Judaism and Christianity. Exiled from the synagogue at the age of twenty for his heretical theories —he was already an admirer of Descartes—and allowing a greedy step-sister to have the fairly comfortable family estate after winning a lawsuit against her, Spinoza lived in poverty as a grinder of optical lenses. He died in 1677 from tuberculosis brought on by the glass dust his work drove to his lungs, comparatively young and after a simple life: he has been acclaimed as the founder of modern metaphysics, moral philosophy and higher criticism.

His Monism and Ideas of God. Spinoza believed that the Universe was One and that this One was a single whole, an entity which is God. Insistence on the universality of God permeated all his philosophy and caused the young German Romanticist, Novalis, to speak of him as 'ein Gottbetrunkener Mensch.' Yet Spinoza was considered by many to be a blasphemer, in so far that he seemed to deny, in a way, free will and the immortality of the soul, and taught that all things, whether good or evil in the eyes of men, were of God. Actually he was insistent on the identification of nature and all her works with God and denied final causes in nature alone: time has shown his brilliant monism in a truer perspective.

Spinoza raised nature to God: he could not conceive that the Deity should create the world out of caprice or in a haphazard way, all of a sudden, out of nothing. As God is all and all is God, Spinoza is a pantheist; hence his appeal to the enthusiastic nature-loving Romanticists of a later age. There is much of the seriousness of his own century, however, in his works. To him the Bible was God's word—though to be treated as a literature critical of Man's life rather than as a dogma to be blindly accepted. Christ was His mouthpiece, sent to teach not only the Jews but all mankind.

Christ and the Scriptures are wisdom and virtue. Christianity, too, teaches humility; and Man's greatness, according to Spinoza, lies in his power to criticize life and despise himself. Just as the Bible aims at securing peace, goodwill and mercy, Spinoza sees in these the hopes for that toleration through lack of which his own century and his own parents had suffered.

Thus he is a pioneer of liberal ideas. Yet he has been called Machiavellian because he seems to suggest that might means right. Actually, his theory is much the same as that of Hobbes, who felt that Man should ' render unto Caesar ' in order to prevent life from being necessarily 'nasty, brutish and short,' as it would be without the existence of society and the State. But he would have his Caesar govern according to the Will of God and so raise his State from the level of the law of nature to that of the law of reason. Thus Man would secure happiness in a true knowledge and love of the universe; and, to Spinoza, knowledge is life. Meantime, while he is still in an imperfect state, Spinoza urged that Man should not ' upbraid God for having given him an infirm constitution or a feeble spirit.' As absurdly ' might a circle complain that God had not endowed it with the properties of a sphere, or an infant, tormented with stone, that God had not given him a healthy body.'

Seeking to explain truth by a coherent theory, Spinoza turned to mathematics and adopted a geometrical method complete with definitions, axioms, propositions, proofs and corollaries. In fact, says Professor Joad, he ' believed with Descartes and Leibnitz that the universe was sufficiently like mathematics for the truth about it to be attainable by the process of *a priori* reasoning from premises which were taken to be self-evident.' He has been criticized because of the insufficient self-evidence of his axioms and definitions, which often seem to presuppose the very conclusion he is setting out to prove: *a priori* methods alone are inadequate.

The Cartesian View of Mind-Body Interaction. Descartes was the first philosopher seriously to tackle the problem of mind-body interaction. He propounded the following solution: God, he held, had created two substances, mind and matter. These proceeded, as it were, on two parallel lines which never intersected. God in His benevolence, in order that life in a material universe might be possible for us, had so arranged things that every event in the mind is accompanied by a corresponding event in the body. The fact that our hair stands on end (bodily event) when we see a ghost (mental event), or that we overflow with good will (mental event) when we have had too much to drink (bodily event), does not imply, as we might have expected, a causal connexion between mind and body. The conjunction of these events is a coincidence brought about by the benevolent intervention of God. The metaphor frequently used in this connexion —it was, in fact, a metaphor of Descartes' successor, Leibnitz (1646–1716)—was that of two perfectly synchronized clocks.

The tick of each clock would inevitably be accompanied by the tick of the other, but this complete correspondence would not mean that the ticking of the one clock was *the cause* of the ticking of the other. It would mean that the clocks had been wound and set together. The conception inevitably involves the need for a winder and setter. Hence, God was invoked to account for the fact that mind and body work together; it is God who ensures that every event in the one will be accompanied by a corresponding event in the other. The influence of God is thus continually operative in the world; it manifests itself at every moment of our waking lives. On these lines Descartes, having radically separated mind and body, invokes the assistance of God to bring them together again.

This theory of the relationship of mind and body (whether or not God is invoked to harmonize them) is known as psycho-physical parallelism.

Leibnitz. Accepting from Descartes the notion of the impossibility of interaction between mind and matter, if they are radically different, Leibnitz denies the difference by virtually eliminating matter. The universe is composed, for him, of an infinite number of independent, spiritual units called monads. No monad can interact with any other monad; hence, its experience is limited to events happening in and to itself. Leibnitz, accordingly, describes the monads as ' windowless,' to indicate that each monad remains shut up within the world of its own experience. The monads do not, on this assumption, know each other. The term monad is defined as an ultimate spiritual unit—ultimate in the sense in which an atom of matter is ultimate.

Nevertheless, there is a pre-established harmony in the universe, the work of the Creator, whereby any event in one monad is accompanied by a corresponding event in all the others. Hence each monad may be said to mirror or reflect the universe, since all the events in the universe have their counterpart in it.

Now the happenings in ourselves of which we are directly aware are mental events—a stream of thoughts, feelings, volitions and so forth. What, then, is matter? Matter is an illusion, due to the monad's confused way of perceiving the world. The monads, that is to say, vary in grades of development, and mirror the world with varying degrees of clearness. The human being is made up of many different monads, including one, the central, guiding monad of the highest development, which is the mind or soul. This mind or soul obtains a reasonably clear view of the world, but one that is still falsified by its conception of matter as apparently real. Only to God, the supreme monad, is the world revealed, under the guise of what Leibnitz's philosophy proves to be its real nature, that is, as a collection of monads.

Here, then, the distinction between the illusory world as it appears, and the world as it really is, is introduced for the first time in Idealism. This distinction later becomes very important, and it may be as well at this stage to say something of its purpose and of the reasons which have led to it.

Appearance and Reality. The world which we know by means of our senses—the world of everyday life—reveals, as Plato showed (*see* Lesson 3, page 141), very serious contradictions when we seek to understand it. In particular, no certain statements can, Plato held, be made about it, since it is continuously in a state of flux or ' becoming.' For this reason it fails to satisfy the intellect, which demands something that can be made the object of certain and definite knowledge. Reality, as conceived by Plato, the world of Forms, satisfied this demand. Again, the world we know is antagonistic to our purposes, thwarts our desires and outrages our sensibilities. We have, therefore, a strong temperamental incentive to hold that this is not the world as it really is—that reality, in short, is different from the world that appears; different and also preferable—more friendly, spiritual, amenable to our wishes.

It is, perhaps, for this reason that all those philosophies which have made a distinction between Appearance and Reality have tended to conceive of the world of Reality as being at once more satisfactory and more satisfying than the world of Appearance. For Hegel (1770–1831), Reality is a universal structure of thought; for Berkeley (1685–1753), the mind of a personal God; for Leibnitz, it is—or at least it embodies—an underlying harmony. All these conceptions are exposed more or less directly to the charge of being rationalizations of human wishes. It is easy by philosophical methods to prove the non-reality of what one dislikes, but the Reality which one substitutes in its stead savours of what the Freudians call wish-fulfilment. Leibnitz's conception of the pre-established harmony introduced into the world by the Creator, in order that the monads might carry on intercourse with each other, involved the conclusion that everything that happens in the world, since it conforms to the harmony, happens in the long run in the best possible way. All, in fact, is for the best in the best of all possible worlds. This view was effectively ridiculed in Voltaire's ' Candide.' The hero of that remarkable book passes through a series of appalling adventures, involving murder, battle, shipwreck, ruin, rape and torture. Upon each incident as it occurs a Leibnitzian philosopher, Dr. Pangloss, is moved to dilate at length, showing how whatever happens, happens, in spite of all evidence to the contrary, for the best, and could not, therefore, have happened otherwise. Comment seems superfluous.

The view that there are two distinct things in the Universe (usually conceived as mind and matter), neither of which can be reduced to the other, is known as Dualism. Dualists, therefore, deny that the Universe is a complete unity.

LESSON SEVEN

Locke, Berkeley and Hume

TRADITIONALLY opposed to the Rationalistic philosophers, Descartes and Leibnitz, are the Empiricists, Locke, Berkeley and Hume. The common starting point of these three philosophers is a thoroughgoing criticism of Rationalism. Denying the existence of *a priori* knowledge, they affirm that we cannot by reasoning alone arrive at the truth about the universe. Reasoning may tell us what ought to be, but it cannot inform us of what is. Therefore, if we want to know what the universe *is*, we must leave the study and go and look; in other words, we must adopt the methods of science. Our knowledge is, they hold, founded on the experience that comes to us through the five senses; in fact, we never have any knowledge other than that provided by the raw material of sense experience.

The philosophy of Locke (1632–1704) begins with a criticism of innate ideas, these being the tools or weapons with which the

Rationalists conceived mind to have been fitted initially, and by the exercise of which it obtained *a priori* knowledge, independently of experience. Locke in his philosophical writings sought to show that such ideas did not exist.

Similarly, Berkeley argues against abstract or general ideas. What is it, he asked, that is before the mind when we think of something abstract and general, like triangle? Plato's answer was the Form of a triangle, and most philosophers have invoked the existence of some kind of general concept or universal idea to explain abstract thinking. This course was not, however, open to Berkeley, since as we do not experience general ideas with our sense organs, it would have involved the admission that we know something that we have not experienced through the senses. Hence, Berkeley argues, when we think of a triangle, what we actually have in mind is some actual particular triangle that we have experienced.

Representationalism. Believing all knowledge to consist of sense experience, the Empiricists were led to consider in detail the nature and analysis of such experience as it comes to us in knowledge of the outside world. Locke's philosophy is, in fact, a sort of psychology. The following is a brief summary of his view of the nature of perception, a view known as Representationalism. The external world consists of entities possessing only primary qualities, such as size, shape, number and occupancy of space. These entities, impinging upon our senses, cause representations or images of themselves to appear in consciousness. It is these representations, called by Locke ideas, and not the external objects that cause them, that the mind knows. But the ideas, unlike the external objects, are invested by mind with secondary qualities such as temperature and colour, which the mind then projects outside itself into the world of objects. The mind is thus conceived after the model of a dark cabinet containing a brightly lit screen illuminated by the light of consciousness. What we know are not objects external to ourselves, but the images of them which are cast by the senses upon the screen of consciousness.

The following quotation from Professor Whitehead's 'Science and the Modern World' admirably sums up Locke's view:

> Thus the bodies are perceived as with qualities which in reality do not belong to them, qualities which in fact are purely the offspring of the mind. Thus nature gets credit which should in truth be reserved for ourselves: the rose for its scent; the nightingale for his song; and the sun for his radiance. The poets are entirely mistaken. They should address their lyrics to themselves, and should turn them into odes of self-congratulation on the excellency of the human mind. Nature is a dull affair, soundless, sceneless, colourless; merely the hurrying of material, endlessly, meaninglessly.

What, according to Locke, there really is in the external is a kind of featureless stuff called substance, which, though itself without qualities, serves as a substratum or foundation for the primary qualities.

Denial of Abstract Ideas. Berkeley abolished the distinction between primary qualities and secondary ones. Whatever reasons there were for believing that the latter were ideas in the mind applied, he held, also to the former. Secondly, and consequentially, he abolished the external world of things, which, though itself unknown to mind, was supposed by Locke to be the cause of the ideas which mind knows. But, if we do not, and never can, know the external world directly, we cannot, said Berkeley, know anything about it; we cannot, therefore, know that it has the property of being able to cause the ideas we do know; and we cannot know that it exists. Putting the point in another way, we may say that, as we never have any sense experience of the external world, but only experience our own ideas, we can only know the external world *a priori*. But *a priori* knowledge for the Empiricist does not exist.

This consideration applies also to Locke's substance, which *ex hypothesi* cannot be known, since it is devoid of qualities by virtue of which alone things can be known. Hence, for Berkeley to say of a thing that it exists is the same as to say that it is known, since whatever is known turns out to be an idea in the mind of the knower. Thus the existence of things consists in their being perceived or known. Berkeley's conclusions and the reasons for them will be considered in greater detail later.

Hume's Scepticism. Hume (1711–76) proceeds still farther along the same lines. Berkeley held that the world continues to exist when we are not perceiving it, because it is perceived by God, who puts the ideas we experience into our minds. But, as Hume pointed out, we have no sense of experience of God, and if, therefore, we are consistent in our rejection of *a priori* knowledge, we cannot invoke His existence to sustain the world when we are not perceiving it. Therefore, there is no reason to believe in the existence of anything other than the ideas we momentarily perceive.

Secondly, we have no experience of a self in and to which the ideas occur. If we try to perceive the self, all that we in fact come across are separate psychological states, e.g. a willing, a fearing, a hoping, or, in the case in question, an endeavouring to see whether we can perceive a self. It is these psychological states that we actually meet; what we never come across is a continuing thread to hold them together; they remain, therefore, distinct isolated entities, a necklace of beads without the thread. Thus Hume reduces subjective Idealism, the position of Locke and Berkeley, to the position known as Solipsism, that is to say, the view that the isolated momentary experiences of the perceiver are the only things that are known to exist in the universe. In fact, they constitute the universe, while it must be remembered that, in the light of Hume's criticism of the self, even 'the perceiver' is only invoked by courtesy. Much subsequent philosophy consists of different attempts to refute this conclusion. It may be said here that, although it cannot be refuted, there is no reason to believe it to be true.

Bishop Berkeley. The philosophy of Idealism is something of a stumbling-block to those who are making their first acquaintance with the subject. The doctrine has had a chequered history and, as put forward by Berkeley, won little acceptance at the time. Pope has a line, 'And coxcombs vanquish Berkeley with a grin.' His views have been 'laughed at, written at, taught at, shrieked at.' Everyone is familiar with the story of Dr. Johnson, that incarnation of the limitations of common sense, who thought he had disposed of Berkeley by kicking a stone.

Every student of philosophy must know from his own experience that there is a stage of mental development in which Idealism appears to be the most monstrous of absurdities. Some will remember having heard at school the quaint notion that the world only exists in our minds or in some Higher Mind than ours; and probably, after the fashion of schoolboys, we characterized this notion as 'rot.' Whatever it is, it is not 'rot,' and whatever our conclusions may finally be, let us remember the advice of Lord Acton—'to understand what we reject as thoroughly as what we accept.'

Idealism and Matter. When we say that Berkeley denied the existence of matter—or, as he would now have to say, physical energy—we do not mean that he denied, or acted as if he denied, the existence of appearances. The difference between him and his opponents is that, while they postulate something behind appearances, Berkeley says this is superfluous. He finds no need to suppose that there is an inaccessible substance underneath all the properties by which we know a thing in the outside world. Those properties are themselves the whole thing. Subject to the qualification to be mentioned below, there is for Berkeley nothing beyond the world of sense, *but*—a world of sense.

What we commonly do, however, is to group together in our minds certain of the properties or qualities from which we infer the external world, and then declare that these inhere in something which we agree to call matter—or, nowadays, energy. According to Berkeley, this matter is a creation of our minds, and has no existence outside them. It is our minds that have put together these qualities and properties, compared them, and then explained them in terms of something behind. But there is no such something behind; to suppose that there is, is a delusion born of our way of thinking. As Berkeley points out, once we admit the existence of such a something, we find ourselves in all sorts of difficulties. The farther we pursue it the more certainly we find ourselves in absurdities and contradictions; but, says Berkeley:

'Upon the whole, I am inclined to think that the far greater part, if not all, the difficulties which have hitherto amused philosophers and blocked up the way to knowledge are entirely owing to themselves—that we have first raised a dust, and then complain that we cannot see.'

Berkeley's Doctrine. Here is the famous passage in which, especially in its last sentence, his theory is stated:

> That neither our thoughts, nor passions, nor the ideas formed by our imagination, exist without the mind is what everybody will allow; and to me it is no less evident that the various sensations or ideas imprinted on the sense, however blended or combined together, cannot exist otherwise than in a mind perceiving them. . . . The table I write on, I say, exists—i.e. I see it, and feel it—and if I were out of my study I should say it existed, meaning thereby that if I was in my study, I might perceive it or that some other spirit actually *does* perceive it. As to what is said about the existence of unthinking things, without any relation to their being perceived, that is to me perfectly unintelligible. Their *esse* is *percipi;* nor is it possible they should have any existence out of the minds or thinking things which perceive them.

If we perceive nothing but our own ideas and sensations, it is impossible to imagine that any one of these ideas, or any combination of them, should exist *unperceived.* Their *esse* is *percipi*—their being is the being perceived. Furthermore:

> When we do our utmost to conceive the existence of external bodies, we are all the while only contemplating our own ideas.

Followed out in its logical entirety, this theory leads Berkeley to the famous passage:

> In a word, all the choir of heaven and furniture of earth—all those bodies which compose the mighty frame of the world—have not any subsistence without a mind; their *esse* is to be perceived or known, and consequently, so long as they are not actually perceived by me, or do not exist in my mind, or that of any other created spirit, they must either have no existence at all, or else subsist *in the mind of some eternal spirit.*

Significance of God to Berkeley. It is sometimes asked: 'Does the room in which we are sitting alone go out of existence when we leave it and therefore cease to perceive it?' The implication of the question is that, since, on Berkeley's view, the room consists entirely of ideas in the mind of the perceiver, when it ceases to be perceived there ceases to be a room. The implication does not follow because of the part played by God in Berkeley's scheme. Because God continues to perceive the room, it continues to exist. The difference between real things and imaginary ones for Berkeley is that real things are those perceived both by God and by us; imaginary ones are perceived by us only. If we ask how Berkeley knows that God exists, his answer is that we have a 'notion' of God. Since this 'notion' does not come to us through the senses, it is perilously like a reintroduction through the back door of the *a priori* knowledge which Berkeley had expelled from the front. It is, however, clear that, unless we are prepared to follow Berkeley in introducing God to give independent reality to a world whose existence, apart from knowledge, has been destroyed, we are reduced to the position that the only things which exist are our mental states and our knowledge of them. His belief presupposes that we are in an intelligible and trustworthy universe.

The Problem of Perception. The philosophy of Berkeley is chiefly famous because it raises in an acute form what is known as the problem of perception. We saw how the logical development of the philosophy of Locke, Berkeley and Hume is Solipsism, or the view that the only things which can be known are the ideas in the mind of the knowing self.

Many people hold that, if we take our start from the Representationalism of Locke—if, that is to say, we hold, as he did, that what we immediately know in perception are not bodies outside ourselves, but representations, pictures or ideas thrown by such bodies on the screen of consciousness—then there is no way of avoiding the solipsistic conclusion. At the same time, it is difficult to see how this view of Locke's can be refuted.

For this reason the problem of perception has become one of the most important in philosophy, especially in modern philosophy, and much of the philosophy that is written today is concerned to answer the question: 'Exactly what is it that I am knowing when, as I say, I see my hand?'

LESSON EIGHT

The Meaning of Existence

In the present Lesson it is proposed to consider from a purely common-sense point of view what reasons, if any, may be adduced in support of the conclusion that, whatever exists, exists only in so far as it is known, and that the nature of existence is, therefore, to be an idea in some knowing mind.

Let us suppose that I press my tongue against my teeth and ask the question: 'What is it that I experience or am aware of?' At first sight the answer would appear to be: 'I am aware of my teeth.' But is this answer really correct? Is not what one really experiences a feeling in the tongue—a feeling caused by the contact between tongue and teeth, but a feeling, nevertheless, and, being a feeling, something that is mental? Suppose, now, that I press my fingers against the table, is what I experience the table? Again, the obvious answer proves on examination to be incorrect. The immediate object of my experience, that of which I am aware, is a sensation in my fingers, a sensation of hardness, smoothness, and coolness.

Let us take a further example. If I stand two feet away from the fire, I experience heat, and say that the heat is a property of the fire. If, however, I move nearer to the fire, the heat increases in intensity, until it becomes pain. Now, the pain is clearly in me and not in the fire; since, then, the pain is only a more intense degree of the heat, the inference is that the heat also was a sensation of mine, and not a property of the fire. The leg of a cheese mite is so small that, except with the aid of a microscope, one cannot see it. Are we, then, to suppose that the cheese mite cannot see its own leg? This seems unlikely. We must infer, then, that the size of the cheese mite's leg varies according to the nature of the mind perceiving it—that the leg has one apparent size for the cheese mite and another for ourselves. But the leg cannot have two different sizes at the same time. Hence, the size turns out to be a property of our seeing, and not of the object seen; it is, in other words, not an intrinsic quality of the object seen, but relative to and dependent upon the nature of the perceiver's mind.

Physicists' Account of Perception. By similar arguments it can be shown that all the qualities apparently possessed by material objects, in their own right, turn out, on examination, to be feelings or sensations or ideas on the part of the perceiver. This conclusion is reinforced by the scientific account of perception. What precisely is it that, according to the scientist, occurs when we see something? Taking first the case of visual sensations, we find that their causation is roughly described in the following terms: a physical object sends out rays of light, which, after travelling through the ether, impinge on the optical nerve; the resulting disturbance in the optical nerve is conveyed along neural cords to the brain, where it causes a further disturbance in the cerebral cortex. It is as a result of this disturbance in the cerebral cortex that we have the sensation of seeing the object; this, in fact, is the physical event which *constitutes* our seeing. Similarly, with regard to hearing. A sound is a vibration in the atmosphere; this vibration impinges upon our ear-drums; the effect produced upon the ear-drums is conveyed by the nerves to the brain; here it causes a disturbance, as a result of which we become conscious, and our consciousness of the cerebral disturbance is called hearing the sound.

Touch Perception. Perception by touch makes the matter even plainer. Suppose that my finger is pressed against the desk. Ordinarily, one would say that there was contact between two material substances. Science, however, lends no countenance to this view. What happens, according to science, is that repulsion is developed between the atoms composing my finger and those composing the desk. The harder the desk is pressed, the stronger the electrical forces which repel my finger. These electrical forces set up in the nerve cells at the end of my finger a current which reaches my brain, as a result of which I experience the sensation of touching the desk. In fact, however, I am not aware of any object external to my body, and, if appropriate parts of my nervous system are suitably stimulated, I shall experience the same sensation of touching the desk, although there is no desk to touch. What is more, I can experience what appears to be a sensation of a pinprick in the non-existent finger of a hand which has been amputated, provided that the nerve terminals in my arm are suitably manipulated.

It is on these lines, and, it might well seem, only on these lines, that it becomes possible to explain the fact of differing perceptions of the same thing. If X sees a cornflower as blue and Y, who is colour-blind, sees it as green, it is very difficult to suppose that the cornflower is both green and blue at the same time. On the other hand, there seems no reason to affirm that it *really* is blue merely because it is blue to normal vision, and to deny that its appearance to the colour-blind man is its *real* appearance because the colour-blind man is in a minority. The plain implication seems to be that the difference between the apparent colours is due to a difference in the physiological machinery of the two perceivers. Moreover, if we take an overdose of santonin, we see everything yellow. Since it cannot be supposed to be the case that this alteration in our visual apparatus has produced a corresponding alteration in that which we see, we can only suppose that the yellowness is the result of a peculiar condition of our seeing. But, if this is true in regard to yellowness, there is no reason why it should not be true in regard to all the colours which we believe ourselves to perceive in the outside world.

Qualities and Substance. It would seem, therefore, that the apparent qualities of things are not possessed by them in their own right, but are effects produced in the mind or the brain of the person perceiving the thing. But if the qualities of a thing are mental, what is left in the outside world? We normally think of an object as consisting of a lump of featureless stuff to which certain qualities belong. It is Matter, to revert to Aristotle's phrase, and the qualities taken together constitute its Form. But let us suppose that you take an object, and one by one strip away all its qualities. What is left? Consider, for example, a chocolate. A chocolate is brown, soft, sticky, and sweet to the taste. Let us abstract these qualities one by one and consider what remains. What is it that had the qualities, but now has them no longer? We may say, of course, that what is left is the chocolate minus its colour, consistency and taste. But is this residue anything at all? If it is, it is only so in virtue of such qualities as we may have left remaining in it; if these qualities, too, were taken away, there would be literally nothing left. There is, that is to say, no substratum or foundation in which the qualities inhere, which is itself without qualities and other than they. If, therefore, the qualities turn out to be ideas in the mind of the perceiver, and, if there is no substance or material foundation besides the qualities, there is nothing left in the end except mind.

Matter, therefore, is an illusion. This is not to say that the tables and chairs which we know in everyday life do not exist; merely that they turn out on analysis to be ideas in the mind of the perceiver. Hence, as Berkeley said, their existence consists in their being perceived or known.

LESSON NINE

Kant: Critical Philosophy and Moral Sense

One of the most important questions in philosophy is the fundamental, sceptical question: can we know anything at all, or rather, can we know it as it really is? Hume's sceptical conclusions had made this question very acute. There is, it is obvious, no necessary reason why the human mind should be an instrument capable of discovering the truth about the universe. The human mind works in accordance with certain prescribed laws of logic, certain rules of reasoning. It holds, for example, that a thing cannot both be and not be at the same time. It holds that if a thing has a quality X, it cannot at the same time not have the quality X. It holds that, if p implies q, and q implies r, then p also implies r. These are laws of logic. There are also mathematical laws: that 3 and 2 make 5, that $a^2 - b^2 = (a + b)(a - b)$, that the sum of the three interior angles of a triangle is equal to two right angles.

Now it is a fact that we believe that these laws apply to the universe outside us. The universe is, we are accustomed to believe, such that a tree cannot both be and not be a beech, and that any three things in it, if added to two things, will make five things. But, for all we know to the contrary, these laws may be laws about the workings of the mind, and not in any sense laws about the workings of the universe. It may be merely that our *minds* are constituted in such a way that they are bound to think that a tree cannot both be and not be a beech, that three and two must make five, and that every cause must have an effect. How do we know that these laws of thought really apply to things? Unless we do know this, we have no guarantee that our knowledge will give us truth about reality. Clearly, then, an inquiry is necessary into the nature and capacities of knowledge, so necessary that, it may be said, all kinds of philosophizing are premature until we have ascertained something about the instrument which we mean to employ. In what sense do we know anything and to what extent?

Kant's Critical Philosophy. To answer this question was the object of Immanuel Kant (1724-1804), and it is one of the most amazing facts in the history of thought that the answer should have waited for so long. It is because the work of Kant constitutes a criticism of men's thought and of the conditions of their thinking that it is generally described as the 'critical philosophy.'

A somewhat uncouth word has also been employed—and is, indeed, now found indispensable—in order to indicate the study with which Kant chiefly concerned himself. This word is *epistemology*, from the Greek word *episteme* (knowledge). Just as biology, then, is the science of life, so epistemology is the science of knowledge. It is the department of philosophy which concerns itself with the knowing process, the conditions, the limits, and the validity of all that we know or think we know.

Certainly, we know something of the external world. Daily life demonstrates the fact. We act on the assumption than an unsupported object will fall, and we are found to be right. So far, so good. There is, at least, open to Man some proximate, practical, working kind of truth. There may be more, but at any rate there is this empirical truth—the word empirical meaning experimental or dependent upon experience. We know that under the present conditions of things the sun will rise tomorrow. That is an empirical truth, demonstrated to be true by experience. But we have still no guarantee that this empirical knowledge of ours is really knowledge about reality. May it not be merely knowledge of the conditions imposed upon reality by our own minds?

This, very briefly, was Kant's position. Our knowledge of the external world, he held, is limited and conditioned by the limit and conditions of our own minds; it is knowledge not of reality, but of appearances. The reality which lies behind those appearances is and must remain unknown.

The two opposed words which Kant employed for appearance and reality were *phenomenon* and *noumenon*. The word, phenomenon, which is so familiar to us, is one of the most important words employed in philosophy, since it expresses, for all those who know its meaning, one of the most important ideas in philosophy. In common use the word means anything that is out of the way or wonderful, and we apply the adjective phenomenal to anything which we wish to signalize as extraordinary. But these employments of the word are unfortunate. The adjective phenomenal should be confined to its proper philosophic use as a description of anything that has the character of a phenomenon. We shall see in a moment how convenient the word may be. A phenomenon, then, is literally an appearance or something that appears: and, whenever we use the word, we are to associate with it in our minds the idea of a something else which, though hidden from us and not apparent, is yet the reality, the self, or the thing-in-itself, lying behind the appearance or phenomenon.

The universe, then, is divided into two sorts of categories of things, the real or the noumenal and the apparent or the phenomenal. Our knowledge is only of what appears to us, and is, therefore, only phenomenal knowledge. It is not suggested that there is necessarily any opposition or contradiction between the real and the apparent. It is asserted merely that our knowledge of reality must always be inferential and can never be direct.

An analogy may serve to make the matter plainer. Let us suppose that I am born with a pair of blue spectacles permanently affixed to the bridge of my nose. Then everything that I shall see will appear blue. This will not be because things really are blue, but because their appearing to be blue is a condition of my seeing them at all—a condition which is imposed upon them by the peculiarities of my visual apparatus. If everybody else is in the same predicament, Mankind will take the same view as I do, namely that everything is blue, because blueness will be a universal attribute of things seen by human eyes.

Kantian Categories. In much the same way, Kant held that the mind was fitted initially with a whole number of sets of mental spectacles, whose peculiarities it inevitably imposed upon everything that it knew. These spectacles are known as the Kantian 'categories.' It is, he held, a condition of our knowing anything at all that it should be in space and time, of a certain quantity, exhibiting certain qualities, the effect of a preceding cause and the cause of some succeeding effect. But this is the case, not because space, time, quantity, quality and causality belong to reality as it is, but because they are categories necessarily imposed by us upon reality as it appears. Of reality as it is, the noumenal world, we can have no knowledge, because in the very process of knowing it we transform it into the phenomenal world, the world as it appears, by the categorizing activities of our own minds.

Kant's Theory of Moral Sense. Some account has been given of the distinction which Kant makes between the world of appearance, the phenomenal world, and the world of reality, the noumenal world. Briefly, we know, and can know, only the world of appearance, because we construct it in the very act of knowing it by imposing the categories of the mind upon it. On the basis of this distinction, we are in a position to give Kant's answer to the question: What right have we to suppose that the laws of thought necessarily apply to the behaviour of things? Kant's answer is that they must inevitably apply to the behaviour of the things *that we know*, because the things that we know are the products of the minds which know them. By the very fact of knowing the world, we have put causality, identity, mathematical relations, and so on into it. Inevitably, therefore, it is found to conform to the mental requirements of logic and mathematics. It is for this reason that science is possible. What we understand by science is simply knowledge of the phenomenal world. Science deals with appearances, with what Kant called 'co-existences and sequences between phenomena,' and science, a product of the human mind, is, therefore, true of the phenomena, which are also products of the human mind. But science does not give us knowledge of reality, which, Kant held, is obtained primarily in moral experience.

Intuitionism in Philosophy. The moral theory occupies a key position in the Kantian system of philosophy, because while our knowledge of the external world is, in Kant's views, phenomenal—that is to say, is knowledge of appearance only—he conceives that when we will and act morally, we are in direct touch with reality. The moral self, Kant held, is truly real, and in experiencing it we establish a direct contact with reality.

Ethical philosophy is discussed at the end of this Course, but Kant's theory is included here because of the closeness of the connexion between his ethics and his philosophy. The theory illustrates a certain type of ethical theory of which it is an extreme example. The type of theory to which it belongs is called 'intuitionist.'

Many writers on ethics have held that actions possess in themselves some intrinsic quality in virtue of which they have ethical value. This quality is recognized as belonging to the action by a special faculty known as the moral sense or conscience. The verdicts of conscience are intuitional; that is to say, though they may be defended by, they are not based upon, reason. They are also final. The moral sense is thus arbiter over all that pertains to the moral sphere, just as the sense of sight is arbiter over what pertains to the visual sphere. Our eyes tell us what is beautiful, and the moral sense tells us what is right, and there is no appeal against either verdict. Now, Kant's theory is intuitionist in the sense that it holds that moral actions are those which proceed from a good will. The essence of the theory is a distinction made by Kant between Man as a moral agent and Man 'from the point of view of anthropology.'

'From the point of view of anthropology' Man is a creature of tradition, environment and training. Morality is the name which he gives to actions of which his society approves, and his own actions are determined by his desire to stand well with his society and by the fear of its disapproval. From this point of view, our opinions on morality are formed not by us, but for us. We get them ready-made, as we get our clothes and shoes from the social shop, being fitted with a code which assures us that it is right to marry one wife and that slavery is wrong, if we are born in a bedroom in Balham, as surely as we are fitted with the contrary beliefs that we may have four wives and, if we are rich enough, a similar number of slaves, if we first see the light in a hut in Central Africa.

Aristotle's Doctrine of Self-Determinism. Not only our beliefs, but our desires are, from this point of view, determined. There is a famous doctrine called self-determinism, bequeathed to us by Aristotle, which puts very clearly the reasons for this view. Aristotle is concerned with the question: why does a man come to have a good character? His answer is: because he has continually performed good acts. But he cannot continually perform good acts unless he is the sort of man whose nature it is to perform them; unless, that is to say, he has the good character from which the good acts necessarily spring. This good character will, in its turn, proceed from and be formed by a preceding series of good acts. Retracing our steps by this method over the past history of the individual, we shall see that the actions which he performs at any given moment spring from, and are conditioned by, his being the sort of person that he is at that moment; and, further, that he is the particular sort of person that he then is because of the impulses which he experiences and the tendencies which he exhibits.

If, therefore, we go far enough back, we can show that the tendencies and impulses which were originally his, on the first occasion on which he acted, are those which really determined the whole subsequent tenor of his life. If we leave out of account the bearing upon the issue of theories of transmigration, we may say that the tendencies and impulses which the individual possesses on the first occasion on which he acts lie outside his control. These tendencies and impulses, which we are accustomed to call hereditary, acting in conjunction with and reacting from the environment in which he finds himself, determine his future actions. By these actions his character is formed. But, since he is responsible neither for his heredity nor for his environment, it would appear that he is not accountable for the actions which these two factors jointly determine, or for the character which is formed by these actions.

Summing up, we may say that our thoughts, desires and impulses are, in every case, the result of what we may describe as a push from behind, for the strength and direction of which we are not responsible.

Kant's Conclusions on Morals. As corollary to the doctrine of self-determinism, we have the doctrine of Man's servitude to his desires and impulses. Man, in this view, is determined not by external forces, but by his own temperament. We can say of any individual, 'he did so and so because he was that sort of person.' Exhibit a man's actions—as psycho-analysis succeeds in doing—as proceeding always from the reaction of his character to a given situation, represent his character at any given moment as the determined result of his past actions, and the chain of causality is complete. So far as ethics is concerned, *tout comprendre c'est tout pardonner* is the only maxim.

Kant admits the conclusions of this analysis, so far as they apply to Man 'from the point of view of anthropology.' So far, he says, as men act according to inclination, do things because they like doing them, or avoid them because they dislike them, their actions are what he calls 'heteronomous,' governed by laws over which they have no control. We often assume, when we are trying to explain human actions, that they are the result of the interaction of character and environment, and are not, therefore, to be praised or blamed, but *understood*. But, in addition to these various likes and dislikes, preferences and prejudices, which can be shown to have been determined for us, there is a further judgement which we make—a moral judgement—which tells us not what we want to do, but what we ought to do. The interesting thing about this judgement is its unqualified character. Its commands are absolute. In the first place, it does not make its injunctions dependent upon the achievement of any end. It does not say, 'if you want to be happy and win the good opinion of your neighbour, or to go to Heaven, then you ought to behave in such and such a way.' It says simply, 'you ought to behave in such and such a way.' Secondly, it is absolute because the obligation which it enjoins is not in the least affected by the strength of our desire to act otherwise than in accordance with it. It does not say, 'you ought to do x, if your temptation to do y is not too great': it says, 'you ought to do x, whatever your temptation to do anything else.' And in saying that you ought to do x, it implies also that you are free to do it. Thus the claim of morality cuts right across the pull of inclination and desire. Considered purely from the point of view of psychology and anthropology, Man is not free; in the moral sphere we act and judge as if we are free.

Now the ground for this claim that we should act from the dictates of duty, irrespective of our likes and dislikes, cannot be found in the phenomenal world, which, as we have seen, yields only a basis for determinism. Therefore, it must be looked for elsewhere. Kant's conclusion is that the moral self belongs to and derives from a world other than the phenomenal world, namely the *noumenal* world of real things, as already described in this Lesson. For this reason its claims are absolute and take no account of likes and dislikes, circumstances and temptations, which are, of course, on Kant's view, all phenomenal.

Kant's Moral Imperative. Kant called the obligation to act morally 'The Categorical Imperative,' because of this absolute command which it makes. To say that it is absolute does not mean that we shall necessarily obey it. We may act usually, even always, as non-moral phenomenal beings. Nevertheless, the claim is there, whether we like to recognize it or not, and it is called absolute because it is completely unaffected by circumstances. Kant, in fact, supplemented his doctrine of the moral will with a number of subsidiary considerations.

For example, he pointed out that right action demands neither explanation, justification, nor incentive. If a person acts wrongly, there is always some special motive which makes him do so. He lies *because* he wishes to convince so and so, steals *in order to* become possessed of so and so. No incentive is, however, required for truth-telling or honest dealing. In so far as we tell the truth or act honestly—assuming that we ever do these things—we do them for their own sake.

Kant derived a number of subsidiary rules from his moral imperative. A famous one is the rule to 'act only according to that maxim which you can at the same time will to be a universal law.' If, that is to say, an action is such that everybody could perform the same action without conflict or self-contradiction, then it will be right. If we permit ourselves a freedom of action which could not be extended universally, then we may be sure that we are going wrong.

An important difficulty may be pointed out. Kant suggests that when we are acting from desire our action is determined. It is only when we act morally that we are free. This suggests that whenever we act from desire—that is, whenever we do what we want to do—we are not acting morally, from which it seems to follow that we can always detect moral action from the circumstance that it is disagreeable. It may, no doubt, be true in practice that right action may generally be defined as the sort of action we dislike doing; but it is certainly not always so, and a theory which suggests that only those actions have moral value which go contrary to inclination is liable to form the basis of an unpleasant and only too familiar kind of Puritanism, one which is never at a loss to prove that we are doing our duty whenever we happen to want an excuse for making ourselves unpleasant.

LESSON TEN

Hegel: Monistic Idealism

HEGEL's philosophy, like that of Kant, is exceedingly difficult, and the student is recommended not to study it intensively until he has a fairly general acquaintance with philosophical arguments and terms. A reading of Hegel (1770–1831) demands a knowledge of Kant's philosophy, from the conclusions of which his own thought in almost every case arises. Hegel is by far the most philosophical of philosophers, just as Bach is the most musical of musicians and Spenser the most poetical of poets. This does not mean necessarily that he is the best of philosophers, but merely that his work exhibits in the highest degree the peculiar characteristics of philosophical reasoning, and, perhaps for that reason, has a special appeal for professional philosophers.

Hegel's Monism. Hegel maintains Kant's distinction between the world of appearance and that of reality, but he conceives the world of reality differently. For him it is not a number of unknown entities (Kant's noumena), but a single, unified structure of thought. If a palaeontologist discovers the thigh bone of an extinct creature—a mammoth, let us say—he is enabled to construct an outline sketch of the whole of the creature from the one bone. This is because the bone has a coherent relation to the whole of the creature's structure. It possesses, as it were, hooks which fit into the eyes of the other bones, and eyes or sockets which receive the hooks of its neighbours. Thus, in virtue of its own characteristics, it determines and, as it were, points forward to, the characteristics of the other bones. Hegel conceived each fragment of the universe, whether thought or thing, on the model of the isolated bone. It had, he thought, hooks which grappled it on to the next fragment of reality; that was again linked to the next, so that the whole formed one coherent, unified structure. Reflecting sufficiently on any one part or aspect of reality, one is led by logical and inevitable stages to the whole, which is a unified structure of thought.

This structure of thought, besides constituting the world of reality, contains within itself the world of appearance also, which is to be regarded as a partially revealed aspect of it. Thus Hegel's philosophy is an extreme statement of the view known as Monism, because it affirms reality to be fundamentally *one* unified whole, the appearance of many different things being regarded as delusive. Since the unified whole with which reality is identified is also a structure of thought, Hegel's philosophy may be called Monistic Idealism. It was first expounded in his 'Phenomenology of Mind' (1807).

Axiom of Internal Relations. Hegel's conclusions follow from two different lines of argument, which deal respectively with the nature of things and with the nature of our thinking about things. The argument about the nature of things is sometimes called the axiom of internal relations, and is as follows.

If we seek to obtain a complete understanding of any one thing, we find that the endeavour involves a necessary reference to other things. This is because, taken by itself, a thing is not self-sufficient. Thus an egg is more oval than a ball, more brittle than leather, shinier than rock, and, if kept too long, it will smell. Now all these facts about the egg involve the relations of the egg to some other object or set of objects, and the egg must have these relations in order that it may be the thing it is Therefore, the relations of the egg to other objects determine, at least in part, its nature, and partially constitute this nature. They are not, strictly, like hooks attached to the egg from outside, linking it to other things; they penetrate into its very being, making it what it is. But the relations also have other ends or terminals, namely, in the things to which the egg is related. Of these things, too, they will, by the same argument, form part of the nature or being. But, if the relations are part both of the egg and of the objects to which the egg is related, the egg and these objects are not really distinct and separate, but form part of the same related structure.

Therefore, the apparent differences between things are illusory; taken in isolation, things are not understandable, because they are not self-sufficient; that is, they are not real.

Theory of Knowledge. Hegel's theory of knowledge—how, that is to say, we know the external world—is a special case of the doctrine of internal relations. The difficulties in regard to theory of knowledge which had been raised by Hegel's predecessors were, he held, due to the fact that the problem had been wrongly formulated. Philosophers had thought of the knowing mind and of the object known as two different things, and of knowledge as a relation which somehow brought them into contact. Conceiving them as initially separate, they had never satisfactorily been able to bring them together. Hegel insisted that knowledge was, initially, a unity containing two aspects—the knowing mind and the object known. Take as an instance the knowledge of the pen with which one is writing. Hegel said, in effect, 'You don't start with a mind or with the pen which the mind knows. You start with an act of knowledge—knowledge of pen.' Knowledge of pen is a unity within which, by a subsequent act of reflection, we distinguish the two sides or aspects—'knowing mind' and 'pen known.' But the unity comes first. It is, so to speak, what is given. The distinction into elements or aspects is secondary and is made by mind for practical purposes. Thus both a mind and a pen are mental abstractions from a prior unity which contains them both. They do not exist in reality as separate isolated things.

The Dialectical Process. Another chain of argument seeks to show that any particular theory or point of view, if pressed to its logical conclusion, leads the mind into contradiction. The student of philosophy is always being confronted with arguments each of which seems irrefutable, but all of which cannot be true, since some of them, at least, contradict others. For example, there are arguments to show that change or motion is unreal, instances of which were given in Lesson 3 (page 142). There are other arguments to show that change, and only change, can be real. Some of these are considered in a later Lesson in connexion with Bergson's philosophy. Both sets of arguments appear to be irrefutable, but they cannot both be true. Again, as we have seen when considering Berkeley, a thing can be shown to be the sum of its qualities; we can find no substance behind these qualities. Yet, if the world were composed of qualities and only of qualities, we should be quite unable to account for the existence of things. Again, there are valid reasons for believing in free will; reasons equally valid for believing in determinism.

Both theories cannot be true, but each undoubtedly seems to contain some truth. If, then, they could be assimilated in a wider theory, which embraced both the contradictory opposites, that wider theory would contain more truth than either taken in isolation. Thus, in its search for truth, the mind is driven forward to a wider view that underlies both the previous contradictory views. This wider view will be confronted with its opposite, and the mind will be driven to formulate something still more embracing. This process, known as the dialectical process, proceeds indefinitely, until we reach the complete view of everything, or the whole truth about everything that is. To this there will be no contradictory. Moreover, since it is related to the whole about which it is the truth, it will, by the Axiom of Internal Relations, be continuous with and part of it. The whole will, therefore, be mental; it will be a structure of thought.

Contradictions of Time and Space. Hegel's philosophy travels many different roads, but all come to the same conclusion. He is continually pointing out the contradictions in the conceptions which the unreflecting mind takes of the outside world. Take, for instance, the concepts of time and space. As a fairly simple example, we will proceed to show that no period of time can elapse. Suppose, let us say, that we take the period of half an hour; now half that period must elapse before the whole of it. This leaves us with a quarter of an hour.

Half this quarter of an hour must elapse before the whole of it. This leaves us with seven and a half minutes. Half of the seven and a half minutes must elapse before the whole of it. In this way we continue to shorten indefinitely the period of time which has to elapse; but, however short the period remaining, it will still be true that half of it must elapse before the whole of it. Something must always happen, therefore, before any period of time can elapse; before this something happens, something else must first happen, and so on *ad infinitum*. Therefore, no period of time can ever elapse.

Space, like time, is infinitely divisible, since however small a piece of space you take, it can always be halved. Space, therefore, consists of infinitely small pieces of space. But to add any number of infinitely small things together, none of which occupies any space, is not to produce space. The conclusion seems to be that time and space will not bear thinking about, because to think about them is to land oneself into hopeless contradictions.

The solution which the Hegelian philosophy offers to these difficulties is to say that they arise because the concepts they involve, e.g. time, space, matter, are only partial, and have been abstracted by the mind from the whole to which they belong and in which alone they have meaning. Take a heart or a lung from a body or a note out of a symphony, and the heart, the lung and the note are, literally, different entities from what they were in the wholes to which they respectively belonged. Let us assume that they were only found in these wholes and never found outside them; then to consider them as they would be in isolation—that is, outside the wholes in which alone they have being—would be to falsify them.

In just the same way, Hegel holds in considering concepts such as time, space and matter divorced from the whole of reality, that we are considering them as they, in fact, are not, and, therefore, inevitably land ourselves in difficulties and contradictions. Restore them to their places as aspects of the all-embracing whole, to which they belong and in which they are found, and the contradictions disappear.

The Absolute. Thus the process of philosophic reasoning leads us forward to a fundamental, all-embracing thought-structure, within which all differences between things are overcome and all contradictions between theories reconciled. This fundamental reality is Hegel's Absolute. All views of the universe other than that taken by the Absolute of itself, being partial, i.e. not the whole truth, are infected with error. It is for this reason that they represent the universe as a collection of different things, and not as a unified structure of thought. The differences are, however, on a deeper analysis, shown to be unreal. Hegel's Absolute is a timeless structure of thought; it is all reality and the only reality. Everything which is, everything which can be thought, consists of different manifestations of the Absolute, which is, nevertheless, wholly present in each of its manifestations.

LESSON 11

Pragmatism and Realism

MOST philosophy since Hegel consists of a succession of reactions from the idealistic monism which has been briefly described. The wholesale reaction of the 20th century from the ways of thought of the 19th has not left philosophy unaffected, with the result that the early years of the century witnessed the rise of a number of different philosophies each of which began by contesting the conclusions of Kant and Hegel. In the first place, the philosophy of pragmatism—a method of thought rather than a system of conclusions—threw doubt on the possibility of absolute truth and absolute knowledge, emphasized the efficacy of human will, and suggested that, in knowing, we make a universe to suit our purposes. Secondly, the philosophy of Bergson criticized the static implications of Hegel's Absolute, the notion, that is to say, that time is unreal and reality changeless, and developed a philosophy from the opposite premise that, literally, the only real thing in the universe is change. Thirdly, and most important of the three, the philosophy known as realism criticizes the idealist notion that things which are known depend for their existence on the knowing mind, and asserts that knowledge plays no part in the creations of its objects.

Realism in its initial stages endeavoured to take a more commonsense view of the universe than the philosophies of Kant and Hegel. Its methods were simple where theirs were complex, empirical where theirs were *a priori* (*see* page 152). Taking its problems one by one, it endeavoured to solve them piecemeal, being content with a series of isolated truths instead of seeking to reach the whole of truth; prepared to study appearances and to abandon the effort to penetrate through to reality. Very soon it proceeded to deny that the distinction between reality and appearance was a real distinction. It is these movements of reaction and the developments which spring from them that will be considered in this Lesson and those Lessons immediately following.

Pragmatism. This is less a system than an instrument for destroying other systems. As formulated by William James, Professor Dewey and Dr. Schiller, it has become the *enfant terrible* of philosophy, deriding the claims of philosophy to be absolutely true, and even denying the possibility of such a thing as absolute truth. Its leading doctrine is that what we mean by truth is 'that which works,' that a true belief is simply one that serves on the whole the purposes of the person who holds it; this cuts at the root of our conviction of the existence of objective truth and the possibility of achieving it. At the same time, pragmatism is a philosophy peculiarly suited to the temper of the age. It embodies the scepticism, the fluidity of hypothesis and the readiness to adopt provisional views and see how they work, of a generation which takes more kindly to the tentative and experimental conclusions of science than to the dogmatic certainties which religion asks us to take on trust. It is also sympathetic to the teachings of evolution, introducing, as it were, a kind of struggle for survival between competing claims to truth and suggesting that the one which seems, or, indeed, *is*, truest is the one which has the greatest survival value.

The basis of the doctrine is a certain kind of scepticism. Traditional theology has professed to be able to prove the fundamental doctrines of religion. Its opponents profess to be able to disprove them. It has subsequently appeared that they are capable neither of proof nor of disproof. William James (1842–1910) assumed that there was no evidence one way or the other for religion. Yet we must, he held, believe something, if only because we have to act.

James's conclusion is that, although there is no evidence in favour of religion, we may as well, nevertheless, believe it, if we find satisfaction in so doing. All belief, he is inclined to suggest, involves risk, since we cannot know any belief to be true. That being so, the test of the truth of a belief will not be conformity with fact, but ability to work—that is, to serve the purposes which led to the belief being entertained.

The Continuum. William James considers that previous philosophical theories are founded on a false theory of perception. Locke, Berkeley and Hume thought the raw material of sensation was a number of distinct, isolated impressions between which the mind never perceived any connexion. James maintained that it was what he called a *continuum*, i.e., a general confused blur into which the perceiver's mind inserted stops and gaps, thus breaking and cutting it up into the world of separate objects we know. Thus the relations between things are actually given in experience no less than the things themselves; what the mind does is to make them explicit. The instruments whereby the mind effects this cutting-up process are concepts, i.e., general ideas in the mind which vary according to the interests and training of the perceiver. Two men with different concepts make different cuts across the continuum of experience, and so perceive different worlds of objects. From this it seems to follow that the mind perceives, on the whole and within limits, what the perceiver likes. Pragmatists do to some extent really hold this belief.

Theory of Truth. Pragmatism proceeds to inquire what it is that, on the whole, makes us think a particular belief true. The answer given is that we shall think it true if it serves our purpose to believe it to be so. We are familiar with the view that religion invents God because men find it necessary to believe in Him, and pragmatism goes on to point out that it is only in so far as it gives emotional satisfaction that any religious belief is entertained. Starting with the position that we think true that which furthers our purposes or gives emotional satisfaction, the pragmatist proceeds to affirm that serving our purposes, or 'working' in practice, is the meaning of truth.

In this connexion he takes as an illustration the procedure of the scientist. Scientific theories first appear as hypotheses, which are entertained for just so long as they work, being abandoned when new evidence is discovered which convicts them of inadequacy. The hypothesis is then modified to embrace the new evidence; the modified hypothesis is found to work—that is, to serve the purposes of the scientist better than the original one—and is, therefore, regarded as true for so long as it does so. Thus scientific theories and even scientific laws are not absolute truths, but are postulates; their truth is continually subjected to review and progressively established by successful tests.

Truth is, thus, provisional and man-made, not something fixed and absolute, but changing as the purposes served by the beliefs that purport to be true themselves change and alter. The more often action on the assumption that a belief is true is found to produce satisfactory results, the truer the belief becomes. Thus the test of the truth of a belief is not conformity with fact, but success in promoting achievement of desires.

Man the Measure of all Things. The pragmatist rejects the common-sense meaning of truth as correspondence with fact, partly because he denies the existence of external independent facts with which our beliefs could correspond. This denial springs direct from the conception of the *continuum.* If reality is conceived as a confused formless blur, from which the mind carves out objects to serve its purposes, it follows that fact, like truth, is a creation of the human intelligence, bearing upon it the imprint of the purposes the fact was created to serve. All knowing, according to pragmatism, is relative to doing. Hence, knowing a fact involves acting in reference to the fact known; thus, to believe in a fact is to alter it. If the belief alters the fact in harmony with our wishes, then, according to the pragmatic theory of truth, the belief in the fact is true, and it follows that the fact asserted by the belief is real. If the belief alters the fact in some way which is not entirely satisfactory, the belief is abandoned and a modified belief is substituted for it. This modified belief will assert a fact of a somewhat different character, which will be more in harmony with the wishes which led us to entertain the belief. Consequently the substituted belief will be truer than the original one, and the modified fact which the belief asserts more real than the original fact. In this way our beliefs make the facts which they assert. Thus Man is the measure of all things, of reality as well as of truth, the relativity both of fact and belief to our interests and purposes being the underlying thread which runs through the whole of the pragmatic philosophy.

Modern Realism. Realism, a comparatively modern movement in philosophy, assumes many different forms, between some of which there is little in common. All Realists, however, concur in rejecting the idealist view of reality as fundamentally mental in character, and the idealist analysis of the process of sense-perception. Most Realists begin, therefore, by addressing themselves to the problem of perception, with a view to refuting the conclusions of Berkeley and exhibiting the object of knowledge as independent of the knowing mind. Among Realists may be mentioned the English philosophers Bertrand Russell, G. E. Moore, S. Alexander, and J. Laird; the American philosophers Professors Holt, Perry, and Montagu; and the Austrian philosopher, Meinong.

Consideration will be given to two typical forms of Realism, the first of which results in a view of the world not widely dissimilar from that of common sense; the second, known as Neo-realism, issues in conclusions remote from those of the ordinary man.

Common-Sense Realism. It is an axiom with most Realists that in perception the knowing mind is brought into contact with and made aware of something other than itself. This proposition is regarded as self-evident.

For Meinong there are three elements involved in perception: (a) act of knowing, (b) object of the act, (c) content of the act. In any two perceptual experiences (a) is the same, being conceived as a bare activity devoid of features. Yet perceiving a table is obviously a different experience from perceiving a chair. That which makes the experiences different is a difference in the respective 'contents' of the two acts, a table content in one case and a chair content in the other, and what makes the contents different is the different objects upon which the acts are directed. But if (a) the act is to be stripped of all features, all the differences between perceptual experiences being referred to (c) the content, (a) tends to become mythological and most Realists prefer to eliminate it altogether. Accordingly, we have theories which postulate only two elements in perception—the act of perceiving (a) which is qualitatively different in any two perceptual experiences; the object (b) on which it is directed.

Now, it is obvious that we cannot say that (a) represents *the whole* of (b) to the mind exactly as (b) is, otherwise it would be impossible to explain how two people have different perceptions of the same object. To meet this difficulty it is necessary to emphasize the activity of the mind in perception. This activity is chiefly shown in two ways: the mind selects from the total situation presented to it, and goes out beyond that situation. Let us suppose, to take an example of Professor Dawes Hicks's, that a botanist, an artist and a colour-blind person are each looking at a red rose (R). In view of the differences between the interests of the first two, we may suppose that their attention will be directed to different aspects of what they see; that the botanist will notice aspect r1, and the artist aspect r2. The colour-blind man, owing to the peculiarities of his vision, will again see a different aspect of the whole R, which we will call r3. Now, although r1, r2 and r3 are all different, we are not justified in supposing that they are therefore mental, or that they do not exist in reality as aspects of the whole R. All the aspects of the objects that different people see are in fact real and given in the actual situations, but different features of the situation are discriminated in or carved out of the given whole by different perceivers, because of the differences in their training and instincts and the consequent differences in what they attend to.

In the second place, the mind obtains fragmentary data in actual perception which it pieces together to form objects. If we look at a table, all we in fact see is a couple of legs, the edge of the table top, part of a shiny brown surface, and so forth. The table itself we do not see. It is the mind which goes out beyond these isolated fragmentary bits of material and puts them together to make a table. Different people may piece their perceptual material together differently; also in the process of going out beyond what is given, the mind, which must of necessity make jumps, may fall into error.

Endeavours are made by Realists on these lines to account for the fact of differing perceptions, while nevertheless maintaining that what is perceived exists independently of the perceiver.

LESSON 12

Bertrand Russell and Neo-Realism

MORE effective perhaps as a refutation of Idealism than the kind of Realism described in the previous Lesson and assuming in recent years great importance in philosophy, is the movement known as Neo-Realism. The most numerous advocates of Neo-Realism are to be found in America, but the Neo-Realist position has been effectively stated in England by Bertrand Russell. In his early book, 'The Problems of Philosophy' (Home University Series), Russell was already pointing out that we have no direct knowledge in sense experience of what are called physical objects. The arguments which he brings forward in favour of this view may be briefly summarized as follow.

Returning to the case of the table (*see* Lesson 11), let us consider what sort of knowledge of it we actually do have. What is it precisely that we experience when, as we say, we perceive a table? A shiny brown patch which we see, a cold hard something which we feel, a sharp hard noise which we hear when we rap the table, and so on. These entities—the shiny brown patch, the cold hard something, the rapping noise—are called sense data (sometimes *sensibilia*), 'things given to the senses,' and it is of these and not of tables and chairs that we have direct experience (what Bertrand Russell calls 'knowledge by acquaintance') when we come into contact with the external world. That the sense datum is not the same as what we call a physical object can be seen from a simple instance. If I put a shilling a foot away from me and a florin three yards away, the shining elliptical patch which is what I see in the place where the shilling is, is larger than the shining elliptical patch I see in the place where the florin is. Yet the florin is larger than the shilling. Physical objects, not being known by acquaintance, are said by Russell, in the book referred to, to be 'known by description.' Our knowledge of them is based on inference and therefore involves a certain amount of *a priori* knowledge.

Sense Data and Physical Objects. The problem raised by the recognition of the fact that what we directly apprehend when we have sensory experience of the external world are not physical objects, but are sense data, raps of sound, patches of colour, smell data, touch data, and so forth, is an exceedingly difficult one. In some way, it is true, we do know physical objects, but it seems very difficult to suppose that we know them directly by means of our senses. What, then, is the relation between the sense data which we experience by means of our senses and the physical objects with which in some way they seem to be connected? If I hold up my finger and look at it, what I shall immediately apprehend is an oblong, pink shape. If I touch it, I shall feel something warm and firm. If I put it in my mouth when I am heated, I shall taste something salty. What, then, is the relation between the oblong, pink shape which is certainly not warm or firm or salty, between the warm, firm something which is certainly not pink, between the salty something which I taste, and my finger?

Various suggestions have been made. It is said, for example, that the sense datum is part of the surface of the physical object. But if we take a case in which the surface of the physical object would not normally be said to have changed, and focus our attention upon the sense datum we actually apprehend, which, on this view, is alleged to be a part of the surface, then the datum perceptibly varies according to the position from which and the conditions under which we look at the alleged part. If, for example, we look at the alleged part from a greater distance, that which we actually see is different from what it is if we look at the part from a smaller distance. It differs again, if we look at it obliquely or if our eyes are affected by santonin, and, most noticeably of all, it is different when we *touch* the alleged part. If the whole surface of the physical object does not change, then no part of it can change; yet the datum, as we have seen, does continuously change, as we change our position of observation.

It seems clear, then, that the datum cannot be identical with any *part* of the surface. Again, it is said that the relation between the object and the datum is that the object causes the datum. But if we always directly apprehend the datum and never the object, we cannot know any of the properties of the object by direct experience. We could only at best infer them from our knowledge of the datum. We do not, therefore, know that the object has the property of being able to cause the datum. We do not, in fact, know by direct experience that the object exists at all. It is for these and other reasons that many writers are inclined to deny that there are physical objects which belong to the external physical world.

Russell's Later Views. In later books, 'Our Knowledge of the External World' and 'An Outline of Philosophy,' Bertrand Russell dispenses with the physical object altogether. If, in experiencing the external world, we never do and never can meet with anything but sense data, what legitimate reason, he asks, is there for supposing that it contains anything but sense data? To postulate a physical object as a hypothetical cause for the sense data, the cause being something which is never known, is like reintroducing Locke's unknown and unknowable substance to be the *cause* of our ideas and impressions.

But, if the external world consists of sense data, why, it may be asked, do we believe in physical objects? Because we correlate together, in virtue of their resemblance to each other and in accordance with the laws of perspective, numbers of sense data which we proceed to regard as being those caused by or associated with a particular physical object.

Sense data are not enduring entities, but have only a momentary existence. Moreover, they are affected by physiological, though not by psychological, conditions in ourselves. The sense datum, however, though affected by the nervous system and brain, is not affected by the mind, nor is it part of the mind. It is an entity independent of mind and known by mind exactly as it is. Thus Idealism forms no part of the view of perception we are considering.

Universals. If we are to limit the activity of the mind in perceiving to bare awareness —if, in fact, the mind knows sense data just as they are, differences between people's perceptions being explained in terms of differences between the sense data perceived —there seems to be no good ground for attributing to mind a different sort of activity in knowledge. Hence, some Realists believe in the independent reality of objects known as universals. When one thinks of justice, the mind, on this view, is in direct contact with a non-mental entity called sometimes a 'universal,' sometimes a 'subsistent object,' the relation of the mind to this object being one of direct awareness. A theory of thinking and, in particular, of the part played by the mind in thinking, has been worked out in America by Prof. Montagu and others on this basis.

LESSON 13

Sense and Perception

THE following considerations are offered in favour of the view that what we directly apprehend in the external world are not physical objects, but sets of sense data; that these, and not objects, are directly perceived. The arguments are mainly taken from C. D. Broad's 'The Mind and Its Place in Nature.'

(1) If I am looking at a bell, nobody would maintain that what I see is, or is identical with, the whole of the surface of the bell. For example, the bell has an inside as well as an outside; yet what I see is a coloured patch of indefinite boundaries, which, although it may be part of the outside, is certainly not part of the inside. Therefore what I see is not identical with the whole surface of the physical object called a bell.

(2) The bell, considered as a physical object, is extended not only in space but in

time; it has a past and a future, and the length of its history from the time of casting to that of demolition is in theory measurable. What I see is a single, comparatively short contemporary event. It may be true that the short contemporary event which is the object of my seeing is also a contemporary slice of the history of the bell, which extends backward into the past and forward into the future, but it is certainly not identical with it.

(3) A bell is more than a coloured surface, and the surface itself has qualities other than that of colour; it is, for example, also hard and cold. What I see when I look at the bell has colour, but is neither hard nor cold. Therefore, what I see is not identical with the surface of the bell.

(4) What I touch when I touch the bell is both hard and cold, but is not coloured. The surface of the bell is coloured. Therefore what I touch is not identical with the surface of the bell. It is also different from what I see when, as I say, I look at the bell. The conclusion is that neither in visual nor in tactile experience is what I directly apprehend by means of my senses the *whole* surface of the bell.

(5) I can be the victim of what are commonly called hallucinations. A hallucination is a state of mind in which I believe myself to see things which would in common parlance be said not to be there. A similar state of mind attends intoxication; the drunkard sees what he calls pink rats in circumstances in which no person who is not drunk sees them, and in which consequently there would be agreement between all sober persons that the pink rats were not there.

Accepting this argument at its face value, assuming, that is to say, that the drunkard's experience is, as we say, delusive, in the sense that there really are no pink rats there, then we are justified in saying that, whatever it is that the drunkard perceives—and he certainly does perceive something—is not identical with a physical object, since in this case no such object exists.

Nor is physical science any kinder. The information which has been obtained by physicists with regard to the nature of matter and of light, and by physiologists with regard to the machinery of perception and more particularly the workings of the nervous system, have an important bearing on the problems under discussion. It is common knowledge that many physicists deny the existence of an external world of solid material things, and are inclined to adopt views not dissimilar from those of Kant, according to which the apparently independent objects of the world outside us are really constructed by our own minds.

Heat and Sound. Heat, according to the physicist's account, is caused by or *is* the energy, both kinetic and potential, of the motion of molecules. Consider, for example, the case of a gas. It consists of molecules, of about a hundred-millionth of an inch across, with comparatively large spaces between them, moving about in all directions with an average speed measured in hundreds of yards a second. The molecules meet and collide, and in consequence of their collision the gas has a certain temperature. If the gas is placed in a flame or hot body, the molecules of which it is composed will gain in energy, moving rapidly and colliding more violently. Imperceptibly the temperature of the gas will go up; heat, as we say, is generated. But the cause of this heat is the greater energy of motion of the molecules; or, to put it as a text-book of physics would put it, heat *is* nothing but the energy of motion of molecules.

Similarly, sound is said to be caused by, or alternatively to *be*, waves in the atmosphere. These waves vary in length, in frequency of vibration and in mode of vibration. Variations in length determine the loudness, in frequency of vibration the pitch, and in mode of vibration the quality of the sound. Sound, then, is produced by atmospheric waves. Atmospheric waves are described as regions of pressure and rarefaction in the atmosphere moving forward with a certain velocity, and the movement of such a region of the atmosphere is the cause of, or *is*, sound. Thus the properties of the atmospheric waves the sounding body gives out determine the character of the sounds.

Smell and Colour. Smell is, or is caused by, or consists of, molecules given off in the form of vapour by the substance which in ordinary language is said to smell. Smell, it is interesting to note, is not even for common sense a property which is attached to the object; a smell, it is thought, is something *given off by* rather than something which belongs *to*. Most significant of all is the case of colour. Colour is often described as a quality of light; it is, at any rate, intimately bound up with light, so that where there is no light, there is no colour. Now light, says the physicist, is, or is caused by, a certain set of wave-lengths of varying frequencies in the electro-magnetic spectrum. Within this section of wave-lengths which are, or which produce, light, certain subsections are earmarked for the different colours. At one end of the section, that containing waves of shortest wave-length and highest frequency, are violet rays; at the other, red rays. Beyond violet are the ultra-violet rays, which are classed with violet for convenience, since they cannot be seen: below red, at the other end of the section, are the infra-red, which equally are red for convenience only. Between lie the other colours. Thus, just as light-waves constitute a particular section of the waves graded according to length and frequency in the electromagnetic spectrum, most of which are not visible, so each colour is constituted by a subsection of waves of particular frequency and wave-length falling within the light section.

These scientific descriptions of the qualities which characterize the world of our everyday experience have an important point in common: the scientific objects in terms of which the qualities are analysed are themselves devoid of the qualities in question. Thus physics takes the ordinary qualities of the world we perceive and analyses them into something else. The world we see is coloured, the world we hear noisy; but the world of physics is neither coloured nor noisy. What, then, has become of colour and noise? The obvious answer is the Idealist one that they are supplied by the mind of the perceiver.

Physicist's View of Perception. Most people would say that the physicist's world is in some sense more real than the sensory world, or at any rate that the physicist gives a truer account of the nature of things than the man in the street; and this view is certainly shared by most physicists. It is desirable, therefore, if we are to determine whether the outside world really contains qualities or not, to consider very briefly what happens, according to the physicist, when, as we say, we see something external to ourselves.

Let us suppose, then, that I am a modern physicist who is looking at a distant object. This object I believe to be a highly complicated set of physical processes, which are electrical in character. I know further that a physical process, which I call a light ray, starts from the object and travels through the intervening medium of the atmosphere, being changed in the course of its journey into another physical process, which ultimately reaches the retina of my eye. Here it is changed into, or provokes, another physical process, which travels along my optic nerve, where it changes into yet another physical process and produces some effect on my brain about which I know very little for certain, but which I assume to be also some kind of physical process.

When this physical process occurs in the brain, there ensues a process of an entirely different kind, namely a *psychological* event which I call seeing. This is directed not upon the physical process in the brain which was the latest physical *cause* in the chain of events which preceded it, but upon what is called the object, which I know in my capacity of physicist to be a set of complicated physical processes which happened earlier in the series of processes than the brain process, this earlier set of physical processes being selected apparently arbitrarily from among the chain of physical processes which preceded the occurrence of the physical process in my brain.

Now this account involves a number of inferences, two of which in particular rest upon assumptions which may be mistaken. I am looking, let us say, at the star Sirius on a dark night. If physics is to be believed, light waves which started to travel from Sirius some years ago reach (after a specified time which astronomers calculate) the earth, impinge upon my retinas and cause me to say that I am seeing Sirius. Now the Sirius about which they convey information to me is the Sirius which existed at the time when they started. This Sirius may, however, no longer exist; it may have disappeared in the interval taken by the travelling light ray. To say that one can see what no longer exists is absurd. It follows that, whatever it is that I am seeing, it is not Sirius. What, in point of fact, I do see is a yellow patch of a particular size, shape and intensity. I infer from my knowledge of astronomy that this yellow patch had an origin, with which it is connected by a continuous chain of physical events, several years ago and many million miles away. But this inference may be mistaken; the origin of the yellow patch which I call a star may be a blow on the nose, or a lamp on the mast of a ship.

Knowledge and Deduction. Nor is this the only inference involved. It is true that I *think* I am seeing a yellow patch, but am I really justified in holding this belief? So far as physics and physiology are concerned, all that we are entitled to say is that the optic nerve is being stimulated in a certain way, as a result of which certain events are being caused to happen in the brain. Are we really justified in saying any more than this? Possibly we are, but it is important to realize that, if we do say more than this, an inference is once again involved, and once again the inference may be mistaken. Directly we go beyond the bare statement 'the optic nerve is being stimulated in such and such a way,' and conclude from this fact 'therefore I am seeing an object of such and such a character,' we are drawing an inference and are liable to fall into error. What, then—if the physicist and physiologist are right—we, in fact, know are certain events in our own brains. The outside world is not itself known; its existence is merely an inference due to the fact that we think these events must have a cause. Perception by touch makes the matter even plainer; again the inference may be wrong.

If we accept the teaching of physics and physiology, what we know in perception are not the movements of matter, but certain events in ourselves connected with those movements; not objects external to ourselves, but the effects of the impact of light rays and other forms of energy proceeding from these objects upon our bodies. This, in general, is the view of the matter which is taken by Sir Arthur Eddington. The external world is for him not something that we perceive, but something that we construct from messages that reach the brain along the nerves. The mind, he says, 'weaves an impression out of the stimuli travelling along the nerves to the brain.' Illustrating this conception, he makes use of a vivid simile, which likens the mind to an editor sitting in his inner sanctum receiving messages from a number of different reporters and, with the aid of a good deal of invention, piecing them together into a story.

The material which reaches the brain along these channels, the material which the mind must utilize for its story-making or word-building, is of the scantiest. Colour, temperature, sound, texture, all are lacking. These are not qualities which are given to us from outside, but qualities with which the mind invests the material which reaches it, 'fancies' which it projects into the external world. Even the structure of familiar things, their 'substantiality' and apparent permanence, are bestowed upon them by the mind.

Idealist Views. It is not difficult to see why physicists adopt idealist views. In contrast to the roundabout and indirect nature of our knowledge of the external world, there are placed the directness, the immediacy and the certainty of the mind's knowledge of itself. Our knowledge of the external world, it seems, is something which results from a long chain of messages which have travelled along intricate and roundabout lines of communication. But, to quote Sir Arthur Eddington, 'there is one kind of knowledge which cannot pass through such channels—namely, knowledge of the intrinsic nature of that which lies at the far end of the lines of communication.' This knowledge, which is direct knowledge of something as it is in itself, is knowledge of a mind. 'Mind,' he says, 'is the first and most direct thing in our experience. All else is remote inference.' We have, he continues, 'an acquaintance with the mental and spiritual nature of ourselves, known in our minds by an intimate contact transcending the methods of physics.' If the one thing which we know as it really is turns out to be a mind, might it not also be the case that other things, if they could be known as they really are, that is to say, from inside, would turn out to be mental, too? Thus we reach the familiar conclusion that the reality of things is probably mental, and that the material world is really a form of appearance which mental existences present to certain finite intelligences and partial points of view. Material phenomena, in fact, are the results of abstraction and selection by our own minds from a spiritual reality which underlies them.

Consciousness and Matter. Sir James Jeans's view of the world as a thought in the mind of its Creator conceived as a Mathematician, is a product of the same line of thought reached by rather similar arguments. Nor are these views, as sometimes suggested, peculiar to English scientists. Famous Continental physicists, such as Einstein, Schrodinger and Planck, incline to think of consciousness as fundamental, and matter as something derived from consciousness.

It should, however, be strongly emphasized that these conclusions are not in any way necessitated. Nor can it be said that they have won much general favour among philosophers. What has happened is that, owing to certain recent developments in physics, many scientists have come to adopt those views of the external world which are to be found either in Berkeley's philosophy or in Kant's. The fact that scientists have come to share the views of these philosophers does not necessarily prove them to be true; nor does it remove the very serious objections to which idealist interpretations of the universe are exposed, which have frequently been pointed out by philosophers in the past.

The state of physics is at the moment too transitional to enable any definite philosophical conclusions to be based upon the theories of physicists. Three main positions which may be regarded rather as starting points for further inquiry than as established conclusions are permissible, and any of them may be adopted. (1) We may take, as Sir Arthur Eddington does, an idealist line and hold that the only thing we directly know is our own experience, that this is continuous with an all-pervading spiritual reality, and that the apparent world of matter is the result of an arbitrary selection from this spiritual reality. (2) We may hold that the only events that we can possibly know are those taking place in our own bodies and brains—this is known sometimes as the 'under-hat philosophy'—and that the external world is merely an inference from these events. (3) We may hold that what we directly know are sense data, and that the worlds both of scientific objects and physical objects are somehow constructed out of sense data. The difficulty of this view is to work out a satisfactory theory of the relations between these different worlds.

LESSON 14

Materialism and Its Critics

MATERIALISM has its roots in the science of the late 19th century, and in order to follow its rise we must retrace our steps some little distance in time and consider the speculations and controversies which began with the publication of Darwin's 'Origin of Species.' Materialism, or the belief that matter, however defined, is the sole type of existence in the universe and that the laws which govern the movements of matter are, therefore, fundamental and all-embracing, was backed by all the contemporary science of the late 19th century. Its main support was, however, derived from biology and psychology.

Darwin's work had shown that the evolution of life upon this planet was a continuous process from the single-celled amoeba, in which it first manifested itself, to its culmination in the human race. This development was achieved by means of a process of natural selection. Variations in species occurred; the offspring would be either more or less suited to their environments than their parents; those that were suited to their environment prospered, chose mates in whom a similarly advantageous variation had appeared, and handed on the variation to their offspring. Creatures that varied in a manner unsuited to their environment died off. As to the cause of the initial variations upon which the law of natural selection operated, Darwin confessed agnosticism. It must be presumed, therefore, that the initial variations were to be ascribed to chance.

The other main theory in the field, that of Lamarck, ascribed the changes in and development of living organisms to the effects upon them of changes in their external environment. As the environment changed, living organisms either succeeded in adapting themselves to it, or they did not. If they were successful, the variation in the organisms resulting from the adaptation gradually became established so that a new species came into being. If they were not, the non-adaptable creature died out.

Both theories had an important point in common. In order to explain the whole process of development that has led from the amoeba to Man, including also the development of intelligence in Man, they found it necessary to invoke neither mind nor purpose, neither creative force nor divine agency; they relied solely upon the operation of natural forces. Darwin ascribed the development to chance variations of which the fittest survived; Lamarck to the automatic adaptation of creatures to their environment. Complete determinism results in either case, since all changes in living organisms, including human beings, will be the result of prior changes in the external environment to which the human being responds. It is obvious, if this view is correct, that, just as the body is relegated to dependence upon its external environment, so a particular theory of the status and function of mind, a theory which equally relegated mind to complete dependence upon the body, is required. This theory was supplied by 19th century psychology.

Interaction of Body and Mind. If body and mind be conceived as completely different sorts of entities, the question of how they manage to interact presents serious difficulties. The attributes of the body are those of any piece of matter—weight, size, mass, occupancy of space, and so forth—and the movements of the body obey the laws of physics. None of these attributes belongs to the mind. The mind has neither weight, nor size, nor shape, it does not occupy space, and its contents are not atoms and electrons, but the stream of thoughts, images, volitions, etc., which make up consciousness. If it has no single quality in common with the body, how can it establish that contact with the body that interaction implies? How can it influence the body or be influenced by it?

Descartes solved the difficulty by regarding the apparent synchronization between mental events and bodily events as due to divine intervention. There was, he held, no causal connexion between mind and body, but God had so arranged matters that any event in the one was accompanied by a corresponding event in the other. This view, known as psycho-physical parallelism, was unacceptable to science, and, since the difficulty of conceiving interaction between entities completely different in kind seemed insurmountable, science met the situation by denying the difference. The body obviously was material; the mind then, it was inferred, must be material, too. Hence arose a conception of consciousness as a very attenuated form of matter, a sort of glow surrounding the brain, whose function was limited to registering or lighting up the events which occur in the brain. Since the glow of consciousness could not light up events which were not there, it followed that nothing could occur in the mind which had not previously occurred in the brain. Hence all mental events were dependent upon and determined by preceding bodily events, and free will was a delusion.

If the mind, a particular sort of emanation from the body, is determined by the body, and the body by events in the external world, the chain of cause and effect leading from movements of matter in the material universe to the thoughts of human beings is complete. The universe in which we live seems to develop according to necessary laws, which are ultimately of the same kind as those studied by physics. Mind and spirit are not fundamental, but late and unimportant arrivals in a material universe, the products of material conditions. Causation proceeds always from the less living to the more. Living organisms are determined by the external environment in which they are placed, and within the living organism the mind is determined by the bodily and nervous system of which it is the mere reflection. Hence, the laws which are appropriate to happenings of every kind are those which govern the movements of small particles of matter. To quote Professor Whitehead:

> Little lumps of material moving in space according to necessary and inevitable laws have produced our hopes, our fears, the scent of the rose, the colours of the sunset and the mystic's experience of God. They have also produced our knowledge of the little bits. Mind, in short, is merely the consciousness of the bits by themselves.

When the conditions favourable to living organisms have passed away, we may expect life to disappear, finishing its pointless journey with as little noise and significance as in the person of the amoeba it began it. Meanwhile, the universe as a whole may be conceived after the model of a gigantic clock, functioning as the result of the automatic interaction of its parts.

The philosophical implications of the materialistic view of the universe are: (1) Free will is an illusion. (2) Mind is an emanation from the body, and the body a product of material forces. (3) There is no purpose or plan in the universe. (4) There is no Creator. (5) The law of cause and effect which operates in the world of matter is ultimate, and applies also to life.

Some Criticisms of Materialism. The materialist theory of the universe is open to criticism from a number of different points of view. From the side of biology, data have been accumulated which make it difficult to believe that the behaviour of living organisms can be adequately interpreted on the assumption that they are merely highly complicated automata reacting to the stimuli of their environment. In psychology, although materialist interpretations have of late years, under the name of Behaviourism, achieved a wide vogue, it is, nevertheless, the case that an adequate account of consciousness in terms of the movements of the brain and the nervous system is as far from being successfully given as it has ever been. The researches of modern physicists into the nature of material things have resulted in a concept of matter at once too vague and too intangible to form any longer an adequate foundation for literally everything that exists. Finally, materialism is exposed to various difficulties of a logical order. If what it asserts is true, thought is only a reflection of, or function of, the brain. I think what I do, not because I am constrained by any external evidence to which I have paid attention and which determines my view, but because my body and brain are in a certain condition. An idea is, therefore, an event of the same type as any other bodily event. It follows that it is meaningless to ask whether an idea is true—as meaningless as to ask whether one's blood pressure is true.

Now materialism is a system of ideas. If, therefore, what materialism asserts is true, materialism is not a statement to the effect that the universe is of a certain kind, it is only evidence that the brains of materialists are in a certain condition. It is, therefore, meaningless to ask whether materialism is true. All that we are entitled to say is that the mental reflections of brains in a certain condition, namely the brains of materialists, produce or are that system of ideas to which we give the name of materialism. Hence, if materialism is true, materialism does not give us information about the universe.

Vitalist Philosophies. In the light of these considerations, there has arisen a movement in modern philosophy which, while taking fully into account the fact of evolution and all that it implies, affirms the primacy of mind or spirit in evolution. The movement takes various forms, of which, perhaps, the most celebrated is that which finds expression in the philosophy of Bergson; another, which will be found in the writings of Samuel Butler and Shaw, has been developed into a general system of philosophy in Doctor Joad's 'Matter, Life and Value'; another is in Professor S. Alexander's famous book, 'Space, Time and Deity'; a fourth is to be found in the works of the Italian philosophers, Croce and Gentile, who, combining the conclusions of Hegel as to the primary reality of mind with the evolutionary conception of mind as a developing dynamic process, find in the experience of the individual spirit of Man, which is conceived as active and changing, a model on which to interpret the universe as a whole.

Theories of this type may, perhaps, most conveniently be studied in the writings of Bergson, an original expositor of the modern vitalist point of view who has the advantage of a capacity for persuasive presentation unequalled since Plato.

The Elan Vital. The main features in Bergson's philosophy are the following. The process of evolution cannot, he holds, be satisfactorily explained in terms of adaptation to environment. A degree of physical adaptation, which is far superior to that exhibited by human beings, was achieved thousands of years ago by the elephant and the tortoise. Why, then, does evolution go on to produce Man, unless it is the embodiment of some purposive force which aims at developing higher *quality* life?

Such a force, called by Bergson the *élan vital*, is affirmed by him to be the fundamental reality of the universe. It is pictured as an ever-active, ever-changing, developing urge, which expresses itself in all the phenomena which constitute the universe.

Bergson is led to this conception by a consideration of the nature of change, and his conception of change is, in turn, derived from an examination of our own consciousness. At first sight our consciousness seems to consist of a succession of psychic states or conditions strung out along the thread of a continuing personality, the ego, much as beads are threaded on a necklace. Closer inspection, however, shows this view to be erroneous, and the error consists in supposing that each particular psychic state or condition remains constant while it persists. In fact, says Bergson, there is nothing in any psychic state but a constant flow of change. Take, he says, 'the most stable of internal states, the visual perception of a motionless object. The object may remain the same. I may look at it from the same side, at the same angle, in the same light; nevertheless, the vision I now have of it differs from that which I have just had, if only because the one is an instant older than the other. My memory is there, which conveys something of the past into the present.' The conclusion is that 'we change without ceasing and the state itself is nothing but change.' The conception that we are beings who endure by change—that we are, in fact, simply elements or currents in a stream of change—is then developed into an account of the universe as a whole. This, too, is conceived as a vast vital surge or activity without beginning or end, the movement which we know as consciousness in ourselves and as evolution in the external world.

Matter and the Intellect. The appearance of solid, static objects extended in space, which the universe undoubtedly presents, is, says Bergson, a figment of the intellect. The intellect is a practical faculty evolved by life to assist the individual in the business of living. Since life in an all-pervasive homogeneous vital surge would present difficulties, the intellect makes cuts across the living flow of reality as a result of which it appears congealed as a number of separate static objects.

Hence, matter is the way in which the intellect represents reality to us. Matter is also envisaged as the backward flow of life. If life is pictured as a fountain jetting into the air, matter is the spent drops that fall back.

Intuition. The faculty by virtue of which we come to apprehend the nature of reality as it is, is not intellect but intuition. This faculty, which is most highly developed in insects, is more akin to instinct than to intellect, and may be best described as instinct guided and informed by intelligence. By means of it, Bergson claims, we can, while attending to the pulse of life within ourselves and sensing the flow of our own consciousness, come to realize that this is but a part or aspect of the same dynamic stream that constitutes the universe itself. The flow of our consciousness is the reality of which we are most indubitably aware, and it is in terms of this psychical flow that reality as a whole is to be conceived.

LESSON 15

Problems of Ethical Philosophy

GENERALLY treated as a separate branch of philosophy, the province of ethics is, however, no less difficult to define than that of philosophy as a whole. Philosophers are commonly agreed that it is concerned with the meaning of such words as 'right' and 'good,' with the nature of duty, and with the validity and character of the obligation which we feel to do our duty. Ethical philosophers have also been concerned to find a criterion by means of which to distinguish right actions from wrong and to lay down the principles of right living. It is very difficult to separate the treatment of these questions from the problems of philosophy as a whole, since the view which a particular philosopher takes in regard to them is largely determined by what may be called his general philosophy. For example, if he is a Materialist he is bound to deny the freedom of the will, since on a Materialist view either the mind is itself a form of matter, or it is determined in respect of all its activity by the movements of the brain. These movements are themselves determined according to the laws of physiology, which can theoretically be derived from physics, and the apparent freedom of the mind must, therefore, be an illusion. If there is no freedom, ethics becomes meaningless. Ethics is a structure built upon the twin pillars of praise and blame, and if a man is not free, it is as irrelevant to praise him for doing what is right as it is impertinent to blame him for doing what is wrong. Thus ethics falls to the ground.

Utilitarian Theories. For the purpose of this brief treatment, ethical philosophies may be broadly divided into two types: (1) those which assess the morality of an action in terms of some intrinsic property or properties alleged to belong to the action, or, sometimes, in terms of the motive from which the action was performed, or the will from which it proceeded; (2) those which assess the rightness or wrongness of an action in terms of the consequences which follow from that action. Theories of the second type, usually known as Utilitarian theories, will first be considered.

The theory of Utilitarianism was first advanced in its modern form by Jeremy Bentham, the socio-legal reformer (1748–1832). It involves two separate sorts of assertions: (a) the ethical value of actions depends entirely on their consequences; (b) of these consequences only pleasure or happiness is to be regarded as valuable. The doctrine involved by this second assertion is Hedonism (from the Greek word 'hedone' meaning 'pleasure').

With regard to the first of these assertions, according to Bentham and J. S. Mill, a right action is one that has the best consequences on the whole. Two points may be noticed. (1) By best consequences is meant best actual consequences, not best expected consequences. If, therefore, an action done with the best possible intentions unexpectedly turns out badly, it is a wrong action. It follows that it is sometimes our duty to do actions which are ethically wrong. (2) As we can never know all the actual consequences of an action, it is impossible to tell with absolute certainty whether an action is right or wrong. Thus Utilitarianism, while it assigns a *meaning* to the words 'right' and 'wrong,' only provides a rough and ready test for measuring the rightness or wrongness of particular actions.

Psychological Hedonism. The doctrine of Hedonism, that 'pleasure is the only good,' is of great antiquity in philosophy. It derives its strength from the fact that, in the case of any action, it is always possible to advance reasons for thinking that it was undertaken with the object of obtaining pleasure for the agent. Stating the theory shortly, we may say that we always do what, after calculating the probable consequences, we think we shall like most. We may, of course, and no doubt often do, make mistakes as to what consequences we shall like most—but the fact that we make such mistakes does not, it is said, invalidate the general truth of the thesis that we do always in fact act in the way which we *think* will give us most pleasure.

Hedonism Criticized. It seems fairly clear that the assertion which some Hedonists make to the effect that pleasure is the *sole* good is mistaken. In the first place, if pleasure is *The Good*, in the sense that everything which is good is pleasure, and *vice versa*, and that there is no good, therefore, except pleasure, then for the word 'good' we may read the word 'pleasure' without any change of meaning. Now, the statement 'pleasure is the good' may be right or it may be wrong, but it can at least be intelligibly discussed with a view to determining whether it is right or wrong. But the statement 'pleasure is pleasure' has no meaning. It is the assertion of an identity. Therefore the statement 'pleasure is the good' cannot mean the same as the statement 'pleasure is pleasure.' Therefore good, or The Good, cannot be absolutely identical with pleasure, from which it follows that good must mean something other than, or at any rate additional to, pleasure.

In the second place, the argument for Hedonism rests upon a false psychology. We can see this by taking a concrete instance. If Hedonism is true, we must all have starved in infancy. If an infant did not suck at the breast, it would starve. On the first occasion on which it sucks it cannot be motivated by the expectation of pleasure or the desire to obtain pleasure, since, if the occasion were *really* the first, it could not know whether it would obtain pleasure from the action or not. Consequently, if, as the Hedonists assert, the only possible motive for any human action is to obtain pleasure, it is impossible to understand why the infant should have sucked on the first occasion—that is to say, it is impossible to understand why it did not starve.

The psychology of Hedonism is based upon two truths which may be stated with some degree of confidence. The first is that the satisfaction of any desire brings some pleasure; the second, that the value of actions depends upon, is indeed ultimately assessable only in terms of, their effect upon some human consciousness. But while it embraces these truths, Hedonism makes assertions which go far beyond them. Because all satisfaction of desire brings pleasure, it does not follow that the motive for all our actions is the desire to obtain pleasure.

In actual experience we desire specific things without really considering whether we shall experience pleasure by obtaining them, and we obey particular impulses without considering whether the results of giving way to them are likely to be more pleasant than those of resistance. The fact that pleasure enriches our mental state when we have obtained the thing or satisfied the impulse does not justify us in saying that, *as a matter of actual experience*, it was our desire to obtain this pleasure which prompted our action. To make this assertion is to put the cart before the horse. Hedonism rests on the assumption that human beings are always rational and purposive, that they always deliberate about the results of their actions and act in order to secure certain specific ends. This belief is a delusion. Many of our actions are purely impulsive in character and are not done with the object of securing any end. When a man breaks the furniture in a rage, boasts, ducks to avoid a flying cricket ball, or shrinks from a ghost, he is not acting with any object at all—certainly not with the object of obtaining pleasure.

Bentham's Utilitarianism. In addition to the psychological doctrine described above, Jeremy Bentham advocated the ethical doctrine that we ought always to promote the greatest happiness of the greatest number. This is not, as would first appear, necessarily inconsistent with the psychological doctrine that we can act only so as to promote our own greatest pleasure, since, according to Bentham, to promote the greatest happiness of the greatest number was also to obtain the greatest possible amount of pleasure for oneself. The reason for this is that society has taken care to secure the performance of those acts which benefit it, by arranging that they shall automatically conduce to the pleasure of the agent. The brave man, for example, is happier than the coward because society rewards bravery, which benefits it, and discourages cowardice, which endangers it.

Mill's Modifications. J. S. Mill introduced two important qualifications into the doctrine of psychological Hedonism, which in effect amount to the abandonment of the view that the pleasure of the agent is the only possible object of desire, and hence that pleasure is the sole good. He introduces a distinction between different types of pleasures. Bentham had said, 'Quantity of pleasure being equal, pushpin is as good as poetry.' Mill, however, held that we ought always to prefer a smaller quantity of a higher pleasure to a large quantity of a lower, that, in short, it is 'better to be Socrates dissatisfied than a pig satisfied.' But, it may be asked, why should we prefer a smaller quantity of higher pleasure, unless that smaller quantity contains some element of value which makes it more desirable than the larger quantity of lower pleasure? This element of value cannot itself be pleasure, since, if it were, the smaller quantity of higher pleasure would be just *more pleasure*. Hence we are driven to admit elements of value which are not pleasure. In the second place, Mill held that it was our duty to promote what he called Social Good, that is to say, the greatest happiness of the greatest number, even when other courses of action more conducive to our own individual happiness are open to us. He abandoned, that is to say, Bentham's contention that the greatest happiness of the individual *always* lies in promoting the greatest happiness of the greatest number, and held that, where they conflict, the latter *ought* to be preferred to the former. Thus, though Utilitarianism may succeed in establishing the validity of the assessment of the ethical value of actions in terms of their consequences, the attempt to establish pleasure as the only consequence of value breaks down.

Moral Sense of Mankind. Many writers on Ethics have held that actions possess in themselves some intrinsic quality in virtue of which they have ethical value. This quality is recognized as belonging to the action by a special faculty known as the moral sense or conscience. The deliverances of conscience are intuitional—that is to say, though they may be defended by, they are not based upon, reason; they are also final. The moral sense, that is to say, is arbiter over all that pertains to the moral sphere, just as the sense of sight is arbiter over all that pertains to the visual sphere. Our eyes tell us what is beautiful, the moral sense tells us what is right; and there is no appeal against either verdict.

In some forms of the moral sense theory it is maintained that good actions are those which spring from or are motivated by a particular part of our nature, and in the most famous form of this theory the particular part of our nature in question is held to be in some sense continuous with, or an expression of, reality.

This latter view was advanced in an extreme form by Kant (*see* Lesson 9). It is only in so far as he acts morally, willing to do his duty whatever the cost, that, according to Kant, a man is free. As a moral agent he escapes from the law of cause and effect which governs the phenomenal world, and acts freely as a member of the real or noumenal world. Translated into psychological terms, the theory may be stated as follows: Man as a member of the phenomenal world is a creature of desire. A complete knowledge of his temperament, past history and dominant impulses at any given moment would enable an observer to predict exactly how he would act in any given situation, *in so far as he acted according to his desires.* In so far, therefore, as he acts according to his desires he is not free. But his moral self, which is expressed in a free will, prescribes for him what is right irrespective of his desires, and, in so far as he follows its dictates, he is acting freely because he is acting in accordance with his own real nature.

Kant's doctrine, then, amounts to this, that we should act in every case in accordance with general principles which the will intuitively recognizes as binding. Unfortunately, this doctrine affords little practical guidance in the doubtful moral situations that arise in everyday life. The general principles which the will lays down are, indeed, rational enough; Kant points out, for example, in regard to them, that they can be universalized, whereas conduct in accordance with the contradictory principles cannot.

It is possible, for example, for everybody to tell the truth, but, if everybody lied, nobody would believe anybody else, and there would be no point in lying. It is, however, obvious that in practice all general principles admit of exceptions—e.g., it is sometimes right to lie to a lunatic—and for these Kant's system does not provide.

Intuitional Judgements. The important part of Kant's doctrine, which is embodied also in that of the other writers of the moral sense school, is his insistence on the special and unique character of the 'feeling'—to use a non-committal word—that we have in regard to certain actions or classes of actions. We recognize instinctively and immediately, it is said, with regard to those actions and classes of actions that they are right and ought to be done, even if we, in fact, do the contrary. It is because of the *directness and certainty* of this feeling that the deliverances of the moral sense are sometimes called intuitions. Thus children and uneducated persons have direct intuitions with regard, say, to the wrongness of lying or cruelty, in virtue of which they condemn lies and cruel actions, even while they practise them, without taking any cognizance of the effects of cruel or dishonest conduct upon society.

That people's moral intuitions differ in different ages and countries is admitted; it is admitted also that analysis may show a close relation between what the moral sense of a people pronounces to be right, and what conduces on the whole to the advantage of the society to which they belong. These facts do not, however, it is said, diminish the authority of our moral judgements. On the contrary, they strengthen it. We should not expect the moral intuitions of savages to be the same as those of highly civilized Man, and, as the evolution of the race progresses, there is no reason why Man's moral sense should not have developed together with his other faculties. As a matter of fact, such progress can be traced in the history of religion. Compare, for example, the high moral code of the New Testament with the savage cruelty of that of the Old. What the moral sense theories assert is, then, that, with regard to certain classes of actions and also, on occasion, with regard to certain individual actions, we experience feelings of approval and disapproval which are ultimate and immediate. These feelings pronounce upon the ethical rightness and wrongness of the actions in question without reference to their social utility, and, though we may not be able to explain or to defend them, we know that they are such as we ought to follow.

Intuitionism of Ends. To these arguments Utilitarians reply that an action divested of its consequences is a mere figment. If dishonesty, for example, did not produce injurious effects both upon the dishonest man and upon his victim, why should we censure it? Hence it is essential to take into account the social effects of actions when assessing their ethical value, those actions, and only those, being right which produce good social effects.

What are good social effects ? As we have seen, the Utilitarian attempt to identify good exclusively with pleasure or happiness broke down. Now when we come to ask what is ultimately good—good, that is to say, in itself and not for the sake of its consequences—there may be a legitimate field for intuition. We cannot give reasons for thinking a thing ultimately good, since such reasons would take the form of showing why it is desirable—i.e. for the sake of what other thing it is desired—and what is ultimately good is by definition desirable in itself.

On the whole, the intuitions of Mankind seem to be in favour of the view that truth, goodness, beauty and, possibly, happiness are all of them ultimately good in this sense. This doctrine, sometimes known as the 'intuitionism of ends,' has been advocated in G. E. Moore's 'Principia Ethica.'

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MATHEMATICS

A SOLID *basis is provided in this Course for the study and comprehension of mathematical principles and methods, from numbers to the calculus, a Course which can be taken as far as the student wishes to proceed in any branch within its outer limits.*

Necessarily compressed, since it was considered that it must cover ground comparable with that of the other scientific and technical Courses in this Work, it includes the major subjects listed below. It is prepared by a brilliant group of instructors in this department of knowledge, a department upon which practically every other form of science is dependent for its progress and practical development.

For Practical Geometry see further in the Course on DRAWING AND DESIGN *(Vol. IV). Another practical aspect is developed in* MECHANICS *(Vol. IV).*

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LESSON ONE

The Number System: Whole Numbers

Mathematics is related to other branches of science in a simple way. Science is concerned with changes that occur in nature—the measurement of these changes, and predictions about future changes based on this. Fundamental in all this lies the study of numbers, how they are used and how new types of numbers have to be invented to represent new varieties of change.

Whole Numbers. A single mark, 1, is perhaps the simplest way to represent a single object. The simplest group of objects could then be represented by the simplest group of such marks, viz., (1, 1) or, '1 and 1.' We find it better to give this group a special mark 2 and we call it *two*. So with a group 1, 1, 1 which we mark 3; and so on. Thus we quickly have the marks 1, 2, 3, 4, 5, 6, 7, 8, 9. The last, 9, stands for 1, 1, 1, 1, 1, 1, 1, 1, 1. Each of these groups has been thought of as made up of single members, but it is easy to see that a group of 9 may be broken up into sets of smaller groups represented by the marks 3 and 6, or 4 and 5, or 2 and 7 for example. Thus we say

9 is equivalent to 3 and 6, or $9 = 3 + 6$
9 " " " 4 and 5, or $9 = 4 + 5$

The mark = is read *is equal to* or simply *equals*.

The mark + is read *add* or even simply *and* or *plus*.

Merely to use symbols to refer to groups does not help us much if we have to invent a special symbol each time we form a new group. This difficulty is overcome in this way. We use 0 to stand for a 'group' with no members—an empty group as it were. We then have groups represented by 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. Now when we form a new group by adding 1 to the group 9, we take the result as a new basic group, a new unit. To write it simply as 1 would confuse it with the more elementary unit, so we write it 'one, nothing' meaning it is 1 large group and no individual members. The obvious mark for this is 10 which in ordinary language is called *ten*.

In this way 12 is one large 'ten-group' and two individuals, 19 is one large 'ten group' and nine individuals. 99 is nine large ten groups and nine individuals. To represent, say, 99 in strokes is a heavy task—hence the economy of this system of numbers. In the same way 100 is ten groups of ten units. If × stands for 'times' then 9×10 stands for 9 times 10, i.e. nine groups of ten units, and 99 is $9 \times 10 + 9$ or 9 groups of ten units to which are added 9 units.

So it is easy to see that any number of objects can be represented by means of the marks 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, and as long as we are dealing only with whole objects these ten marks suffice for our purpose. Of course there are words in the language for the larger groups—ten groups of ten we call *one hundred*, ten groups of one hundred is *one thousand*, a thousand groups of one thousand is *one million*, and these we write respectively 100, 1000, 1000000.

How many whole numbers (called *integers*) are there? Clearly there is no end for we can always add one to find another. Thus:

1, 2, 3, 4, 5, ...is unending.
The numbers 1, 3, 5, 7, ...are called *odd*.
The numbers 2, 4, 6, 8, ...are called *even*.

Two times any number is always an even number. If we write N for any number, $2 \times N$ or more simply 2N is an even number.

Addition. If we add 1 to an even number we get an odd number. Thus $2N + 1$ is always an odd number no matter whether N itself is even or odd.

It should now be clear how *addition* takes place. To add 135, 243, 274 we write them under each other like this.

$$\begin{array}{r} 135 \\ 243 \\ 274 \\ \hline 652 \\ \hline \end{array}$$

Add up the units $4 + 3 + 5 = 12$. This represents one group of ten and 2 units. Accordingly we write 2 in the answer to the extreme right and add 1 group of ten to $7 + 4 + 3$ which are groups of ten. The result is 15 groups of ten, i.e. 1 group of 100 and 5 tens. Thus we place 5 next to the 2 in the answer and add 1 to the hundreds giving $1 + 2 + 2 + 1 = 6$.

The final result is therefore 652. The same procedure is followed for larger numbers.

Subtraction. The opposite process to addition is *subtraction*, and for this we use the sign − (pronounced *mīnus*). It stands for the word ‘less.’ Thus 7 − 4 = 3 reads ‘seven minus four equals three.’ We leave it to the reader to justify the ordinary procedure for subtraction.

Multiplication and Division. Multiplication and division are merely more elaborate forms of addition and subtraction.

$$\begin{array}{r} 1428 \\ 7 \\ \hline 9996 \\ \hline \end{array}$$

Thus, in the adjoining example, 7 groups of 8 are 56 units, that is 5 groups of ten and 6 units. The 6 is written down and the 5 added to the next set of 10s, viz., 7 groups of 2 tens + 5 = 19 groups of 10. The 9 is written down and the 1 carried forward, and so on.

Again 1428 × 17 means that we have to take 1428 groups of 7 units and add it to 1428 groups of ten units, and this is effected quite simply by the following scheme

$$\begin{array}{r} 1428 \\ 17 \\ \hline 9996 \\ 1428 \\ \hline 24276 \\ \hline \end{array} \qquad\qquad \begin{array}{r} 17 \\ 1428 \\ \hline 136 \\ 34 \\ 68 \\ 17 \\ \hline 24276 \\ \hline \end{array}$$

Here we see that 1428 times 17 is the same as 17 times 1428. It is clear that this must be true in general, for M rows each containing N items can also be regarded as N rows each containing M items.

Division proceeds in the same way. If we have to divide 1428 into 7 equal groups we can see that 14 hundreds will divide into 7 groups of 200 each, and 28 units into 7 groups of 4. Thus:

1428 divided by 7 is 204

or 1428 ÷ 7 = 204, or 1428/7 = 204, or $\frac{1428}{7}$ = 204

Each of the marks ÷, /, and —, means ‘divided by.’ The method is really equivalent to subtracting 204 seven times from 1428.

Now if 1428 can be separated into 7 groups of 204 each, it is equally clear that it can be separated into 204 groups of 7 each. Stated otherwise this says that

$$1428 \div 7 = 204, \quad 1428 \div 204 = 7,$$
$$1428 = 7 \times 204$$

Thus every problem in division is at the same time a problem in multiplication. Here is the systematic way in which the division would be performed. Let us divide 149527 by 413.

$$\begin{array}{l} 413)149527(\underline{\underline{362}} \\ \underline{1239} \\ 2562 \\ \underline{2478} \\ 847 \\ \underline{826} \\ \underline{21}\text{ units} \end{array}$$

We follow precisely the same method as in the simple case. We take the first four numbers 1495 ignoring the other two except to recognize that we are really dealing with 1495 hundreds. The largest whole number of times 413 divides into this is 3. Multiplying 413 by 3 gives 1239. Taking this from 1495, leaves 256, and since it was 1495 *hundreds*, we are left with 256 hundreds, or 2560 tens. Actually the original number was not 1495 hundreds but this plus 2 tens and 7 units. Accordingly we have 256 hundreds and 2 tens to consider, so we bring the 2 down alongside the 256, giving 2562 tens. Now 413 divides into this 6 times. We place the 6 in the *tens* position in the answer alongside the 3, and note that 6 times 413 is 2478. Taking this from 2562 leaves 84 *tens*. So far we have left out of account only the 7 units in the original number; this with the 84 tens is equivalent to 847 units and 413 will divide into this 2 times, leaving 21 units over.

Thus finally we can say that 149527 can be split up into 413 equal groups each of 362 items, and 21 items are left over, an amount itself too small to be distributed among 413 equal groups. Thus:

$$149527 = 413 \times 362 + 21 \text{ over}$$

Factors. If one number divides exactly into a second number the former is said to be a *factor* of the latter. To *factorize* a number is to write it as the product of factors.

Thus 2, 7, 9, 20 are all factors of 2 × 7 × 9 × 20, that is of 2520. Notice that some of these factors can themselves be factorized. Thus:

$$9 = 3 \times 3, \; 20 = 2 \times 2 \times 5$$

Prime Numbers. A prime number is one which has no factors other than itself or 1. Thus 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, . . . are all prime numbers. It can be shown that there is no greatest prime number.

Prime Factors. When a number has been factorized and all the factors are prime numbers, these factors are called prime factors. Thus:

$$2520 = 2 \times 2 \times 2 \times 3 \times 3 \times 5 \times 7$$

These are a few simple rules for finding factors.

1. Every even number has the factor 2
2. If the sum of the *digits*, or individual figures,

in a number is divisible by 3 or 9, then 3 or 9 is a factor of that number.

3. If the sum of the 1st, 3rd, 5th . . . digits of a number equals the sum of the 2nd, 4th, 6th . . . digits, the number is divisible by 11.
4. If a number ends in 5 it is divisible by 5.
5. If a number ends in 0 it is divisible by 10.

Least Common Multiple. What is the smallest number into which 24 and 36 will both divide exactly? They will evidently both divide into 24 × 36, but is this the smallest number? Now

$$24 = 2 \times 2 \times 2 \times 3$$
$$36 = 2 \times 2 \times 3 \times 3$$

The least number into which they both divide exactly—the *least common multiple*, abbreviated to L.C.M.—must clearly have three 2's and two 3's, the former because 24 requires this, and the latter because 36 requires it. Thus it becomes clear that the L.C.M. of these two numbers is $2 \times 2 \times 2 \times 3 \times 3 = 72$.

(We shall require this when adding or subtracting fractions.)

Highest Common Factor. This is the largest factor common to any given set of numbers. For example, if we look at the factors of 24 and 36 we can see that the highest factor in common is $2 \times 2 \times 3 = 12$. It is usual to write H.C.F. for 'highest common factor.'

EXERCISES

To be worked by the student. Answers appear in the following Lesson.

(1) Complete the statements: $7 = 1 +\ \ $, $24 + 3 =\ \ $, $4 + 7 = 1 +\ \ $, $9 = 12 -\ \ $.
(2) Add together 27, 42, 121.
(3) Add together all the odd numbers up to, and including, 17.
(4) Add one thousand and eight to two hundred and forty-seven. Then subtract six hundred and eighty from the total.
(5) Multiply 184 by 27.
(6) Verify that 342 × 16 is same as 16 × 342.
(7) Divide 64 into 1088.
(8) Find what is left over when 2683 is divided by 51.
(9) Find the prime factors of 105, 62, 1155.
(10) Find the L.C.M. and H.C.F. of 25 and 155; 6, 9 and 21; 24 and 56.

LESSON TWO

The Number System: Fractions

So far we have dealt only with whole numbers, and we know what we mean when we say—' divide 27 by 3 or divide 19 by 6 .' The answer to the former is 9, and to the latter 3 with 1 unit over.

Is there a reasonable meaning to be attached to the statement ' 1 can be divided by 2 ' ? In fact we contemplate throwing overboard the restriction that the number divided (*numerator* or *dividend*) must be greater than the number dividing (*denominator* or *divisor*).

Now if we are dealing with a single group of 12 objects it is clearly possible to divide it into 2, 3, 4, or 6 parts so that we could talk sensibly of

$$1 \div 2 \text{ or } \frac{1}{2},\ 1 \div 3 \text{ or } \frac{1}{3},\ 1 \div 4 \text{ or } \frac{1}{4},\ 1 \div 6 \text{ or } \frac{1}{6},$$

of the group. This would also be true if it were a length of distance or time, or the weight of a heap of sand. We see that sub-division is a normal physical process. A number that represents any element or group of elements into which a unit has been subdivided is called a *fraction*. In that sense

$$\frac{1}{2},\ \frac{1}{3},\ \frac{1}{4},\ \frac{1}{5},\ \frac{1}{6},\ldots\ldots,\ \frac{2}{3},\ \frac{2}{4},\ \frac{3}{4},\ \frac{2}{5},\ \frac{3}{5},\ \frac{4}{5},\ldots\ldots$$

are all *fractions*.

To divide two units into three equal parts (each of which is therefore 2/3) is the same as dividing two separate units each into three parts and adding together two of the elementary parts. Thus

$$\frac{2}{3}=\frac{1}{3}+\frac{1}{3},\quad \frac{2}{4}=\frac{1}{4}+\frac{1}{4},\quad \frac{3}{5}=\frac{2}{5}+\frac{1}{5}=\frac{1}{5}+\frac{1}{5}+\frac{1}{5}$$

Fractions in their Lowest Terms. Two quarters are clearly equal to one half; so also are three sixths or four eighths, etc. Thus:

$$\frac{2}{4}=\frac{1}{2};\ \frac{3}{6}=\frac{1}{2};\ \frac{4}{8}=\frac{1}{2}$$

Now in each of the fractions 2/4, 3/6, 4/8 there is a factor common to the *numerator* and the *denominator*, i.e. the number at the top, and that at the bottom, and it would appear that in these cases this common number may be cut out without affecting the value of the fraction.

Is this true in general? Can we always cancel out a common factor?

This must be so as we can see in any special case. Suppose for example we have 10/13 which is the result of taking a thirteenth part of something ten units long. If we take this say 60 units long instead of 10, we should require to divide this not into thirteen parts but into many more parts, viz., six times thirteen parts in order to obtain the same final length. Thus:

$$\frac{10}{13} = \frac{6 \times 10}{6 \times 13}$$

Also if we care

$$\frac{10}{13} = \frac{7 \times 10}{7 \times 13} = \frac{7 \times 6 \times 10}{7 \times 6 \times 13}$$

Reversing this process we can write, say—

$$\frac{105}{117} = \frac{3 \times 5 \times 7}{3 \times 3 \times 13} = \frac{5 \times 7}{3 \times 13} = \frac{35}{39}$$

$$\frac{84}{108} = \frac{2 \times 2 \times 3 \times 7}{2 \times 2 \times 3 \times 3 \times 3} = \frac{7}{3 \times 3} = \frac{7}{9}$$

When all the factors that are common to numerator and denominator have been cancelled out as in these two illustrations the fraction is said to be reduced to its *lowest terms*.

Addition and Subtraction of Fractions. The foregoing considerations can be used for addition of fractions in this way:

$$\frac{1}{2} + \frac{3}{4} = \frac{2}{4} + \frac{3}{4} = \frac{5}{4}$$

$$\frac{7}{15} + \frac{3}{10} = \frac{7}{3 \times 5} + \frac{3}{2 \times 5} = \frac{7 \times 2}{2 \times 3 \times 5} + \frac{3 \times 3}{2 \times 3 \times 5}$$

$$= \frac{14}{30} + \frac{9}{30} = \frac{23}{30}$$

The denominator of each fraction is written in terms of its factors, and the least common multiple is found for all the denominators. Each fraction is then brought to a form with this least common multiple as denominator and the addition follows at once. Thus consider:

$$\frac{5}{168} + \frac{3}{280} + \frac{1}{42}$$

Here

$$\begin{aligned} 168 &= 2 \times 2 \times 2 \times 3 \times 7 \\ 280 &= 2 \times 2 \times 2 \times 5 \times 7 \\ 42 &= 2 \times 3 \times 7 \\ \text{L.C.M.} &= 2 \times 2 \times 2 \times 3 \times 5 \times 7 = 840 \end{aligned}$$

$$\frac{5}{168} = \frac{25}{840}, \quad \frac{3}{280} = \frac{9}{840}, \quad \frac{1}{42} = \frac{20}{840}$$

Hence

$$\frac{5}{168} + \frac{3}{280} + \frac{1}{42}$$

$$= \frac{25}{840} + \frac{9}{840} + \frac{20}{840}$$

$$= \frac{54}{840} = \frac{2 \times 3 \times 3 \times 3}{2 \times 2 \times 2 \times 3 \times 5 \times 7} = \frac{9}{140}$$

Quite obviously subtraction may be carried through in the same way. Thus:

$$\frac{5}{168} - \frac{3}{280} + \frac{1}{42}$$

$$= \frac{25}{840} - \frac{9}{840} + \frac{20}{840}$$

$$= \frac{25 - 9 + 20}{840} = \frac{36}{840} = \frac{3}{70}$$

Proper and Improper Fractions. So far we have thought of fractions as numbers less than 1, where the numerator is less than the denominator. Such a fraction is called a *proper fraction*. There is no reason however why the form of sub-division we have used to produce fractions should not be applied to cases where the numerator is greater than the denominator. For example we could divide 6 into 3 parts and write it as:

$$\frac{6}{3} = \frac{2}{1} = 2$$

$$\text{Or, } \frac{4}{3} = \frac{3 + 1}{3} = \frac{3}{3} + \frac{1}{3} = 1 + \frac{1}{3}$$

$$\frac{22}{7} = \frac{21 + 1}{7} = \frac{21}{7} + \frac{1}{7} = 3 + \frac{1}{7}$$

We use the term *improper fraction* for one in which the numerator is greater than the denominator, and in such a case we can always rewrite it, as above, as a whole number plus a proper fraction. This we can do either by the method shown above or by dividing the denominator into the numerator and forming the fraction by using the remainder for this purpose. For example we have found that 149527 when divided into 413 parts gives 362 and a remainder of 21 over (Lesson 1). Thus:

$$\frac{149527}{413} = 362 + \frac{21}{413} = 362 + \frac{3}{59}$$

Note. It is usual to write combinations such as a whole number plus a proper fraction, like $3 + \frac{1}{7}$, or $362 + \frac{3}{59}$, as $3\frac{1}{7}$ and $362\ \frac{3}{59}$

Powers of Numbers. Consider the numbers:

$$5,\ 5 \times 5,\ 5 \times 5 \times 5,\ 5 \times 5 \times 5 \times 5,\ 5 \times 5 \times 5 \times 5 \times 5, \ldots.$$

which for simplicity we write

$$5^1,\ 5^2,\ 5^3,\ 5^4,\ 5^5,\ \ldots.$$

The numbers written above are called the *powers*.

Thus

10, 100, 1,000, 10,000, 100,000, 1,000,000,....

are

$$10^1,\ 10^2,\ 10^3,\ 10^4,\ 10^5,\ 10^6.$$

One million is 10 to the power 6. It is not customary to write the figure 1 for the first power for there we are dealing only with the number itself. Thus we could write:

$$24 = 2 \times 2 \times 2 \times 3 = 2^3 \times 3$$
$$36 = 2 \times 2 \times 3 \times 3 = 2^2 \times 3^2$$
$$2400 = 2^3 \times 3 \times 10^2 = 2^5 \times 3 \times 5^2$$

A number raised to the power 2 is said to be *squared*, because, as we shall see, the area of a square, the length of whose side is measured by the number, is itself measured by the same number raised to the power 2.

A number raised to the power 3 is said to be *cubed* because, as we shall see, the volume of a cube, the length of whose side is measured by the number, is itself measured by the same number raised to the power 3.

Note. $2^3 \times 2^4 = 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 = 2^7 = 2^{3+4}$

$10^2 \times 10^3 = 10 \times 10 \times 10 \times 10 \times 10 = 10^5 = 10^{2+3}$

If two powers of the same number are multiplied the result is the same number raised to the sum of the powers.

Negative Numbers. We have indicated that mathematics is the servant of science. It has to discover the kind of numbers and the kind of numerical operations that represent those changes in nature that can be measured. So far we have dealt with whole numbers and fractions, both of which clearly are needed in describing simple counting operations and in forming smaller groups from larger groups. We now propose to extend both these ideas of number. If you will watch any kind of indicator or measuring instrument such as one that shows pressure or temperature you will see that there is a certain normal position of the pointer usually referred to as the 'zero position.' When the temperature or pressure is greater than this, the pointer moves to one side or rises above the zero mark; when it is less than the normal the pointer moves to the other side or falls below the zero mark. It is clear that confusion would arise if you were merely to state, for example, that the temperature is ten degrees (or whatever the unit may be) away from the zero; we must indicate whether it is above or below, to one side or the other, as the case may be.

How are we to indicate this? As a matter of fact we already have two symbols which stand for these, + and −. When we have written +10 we have meant 'add 10' to what preceded it, and when we have written −10, 'take 10 away.' In this case what precedes it is simply the zero position, viz. 0. Thus +10 degrees on a thermometer would mean that it shows 10 degrees *above* zero and −10 degrees a reading 10 degrees *below* zero. −10 degrees is as reasonable a temperature reading as +10 degrees. It is therefore necessary for scientific reasons to consider that when we talk of 10 or 8 we mean +10 or +8 and when we talk of −10 and −8 we are equally indicating a real type of number.

What is true of whole numbers is quite clearly equally true of fractions. In future, therefore, we shall accept negative whole numbers and negative fractions as valid forms of number and they will be indicated by the presence of a minus sign before them. When we have positive numbers we may or may not insert the positive sign.

EXERCISES

Answers appear in the following Lesson.

(1) Reduce the following fractions to their lowest terms:

$$\frac{16}{64}, \frac{81}{108}, \frac{19}{95}, \frac{168}{228}$$

(2) Complete the following statements:

$$\frac{2}{7} + \frac{1}{5} = \frac{}{35}, \quad \frac{3}{11} + \frac{1}{4} = \frac{}{44}, \quad \frac{1}{12} + \frac{2}{9} = \frac{}{36}$$

(3) Add together $\frac{1}{11}, \frac{3}{8}, \frac{1}{6}$

(4) Find $\frac{1}{16} + \frac{3}{8} + \frac{5}{12}$

(5) Find $\frac{7}{9} + \frac{3}{4} - \frac{9}{10}$

(6) Show that $\frac{1}{2} + \frac{1}{3} + \frac{1}{4} = 1 + \frac{1}{12}$ and that $\frac{7}{8} + \frac{1}{2} - \frac{3}{16} = 1 + \frac{3}{16}$

(7) Show that $9 \times 81 = 3^6$; $7 \times 21 \times 9 = 7^2 \times 3^3$; $16 \times 24 \times 729 = 6^7$

Answers to Exercises in Lesson 1

(1) 6, 27, 10, 3 (2) 190
(3) 81 (4) 575
(5) 4968
(7) 17 (8) 31
(9) 3, 5, 7; 2, 31; 3, 5, 7, 11
(10) 775, 5; 126, 3; 168, 8

LESSON THREE

The Decimal System

CLOSELY interwoven with our method of writing numbers are *Powers of Ten.* Since, for example, 24 stands for 2 groups of 10 plus 4 units.

$$24 = 2 \times 10 + 4$$

The 4 is added of course *after* the multiplication is performed. In the same way—

$$\begin{aligned} 396 &= 3 \times 100 + 9 \times 10 + 6 \\ &= 3 \times 10^2 + 9 \times 10 + 6 \\ 1428 &= 1 \times 10^3 + 4 \times 10^2 + 2 \times 10 + 8 \end{aligned}$$

so we see that the power of each 10 tells us the place occupied by the number multiplying it. Again in 11111 each 1 has a value equal to 1/10th of the 1 to its left. Of course the least important place is 1 on the extreme right which represents just 1 unit. But if we use the principle that each 1 represents 1/10th of a 1 to its left we ought to be able to represent fractions in this way by extending our numbers to the right beyond the unit place, provided we make clear where the unit place is. This we do by placing a dot after it. Thus 1·1 represents 1 unit (the left 1) and 1/10th of a unit (the right one). In this way 1·2 would represent 1 unit and 2/10th; 1·3, one unit and 3/10th and so on. For example—

743·9 stands for $7 \times 10^2 + 4 \times 10 + 3 + 9/10$

The latter is a cumbersome way of writing, as a set of whole numbers and a fraction, something whose meaning is quite clear in the form 743·9. Notice that one of the positions might be occupied by a 0 and this would not affect the meaning to be attached to any subsequent number. For example 20·8 still means 20 and 8/10th.

Addition, Subtraction, Multiplication of Decimals. The convenience of writing numbers in this way will at once be apparent. Adding ·4 to ·6 would give us 10 after the decimal point but 10/10th is simply 1 unit, so we carry this forward to the next column in the usual way and the scheme fits into the ordinary method of addition. The decimal point showing where the unit stands is maintained throughout. The same applies to subtraction, the result in the foregoing case being evidently 86·2.

$$\begin{array}{rr} \text{Add} & 275{\cdot}6 \\ \text{to} & 189{\cdot}4 \\ \hline & 465{\cdot}0 \\ \hline \end{array}$$

To multiply 275·6 by 4 we note that 4 times $\frac{6}{10}$ is 24/10 which is 2 and 4/10, i.e. 2·4 so the sum stands simply

$$\begin{array}{r} 275{\cdot}6 \\ 4{\cdot} \\ \hline 1102{\cdot}4 \\ \hline \end{array}$$

Had we required to multiply by 4·2 however we must note that while multiplication by 4 stands as in the above, the multiplication by 2 is really by 2/10, i.e. divide by 10 and multiply by 2. To divide by 10 we have simply to reduce the power of 10 attached to each digit and this, as will be clear, is equivalent to moving the decimal point one place to the left. We then carry through the multiplication by 2. The steps should be clear in the calculation above.

$$\begin{array}{r} 275{\cdot}6 \\ 4.2 \\ \hline 55{\cdot}12 \\ 1102{\cdot}4 \\ \hline 1157{\cdot}52 \\ \hline \end{array}$$

Usually we do not trouble to enter the decimal point until the end. The multiplication is carried through in the usual way as if no decimal points were present, and the latter inserted either by using one's intelligence to decide the size of the whole number (e.g. 4 times 275 is rather greater than 1000 and therefore the decimal point must be after the 4th figure from the left) or according to the following rule: Count how many decimal figures occur in the multiplying numbers to the right of the decimal points. There are two, one in each number. In the answer the decimal point must be followed by two numbers.

Extending the Decimal. It is clear that so far every number could not be represented by a decimal number for, since only one figure occurs after the decimal point, the small jump between numbers is 0·1, i.e. 1/10 of a unit. For example, after 0·8 comes 0·9 and after 0·9 comes 1·0. As there are obviously numbers between 8/10 and 9/10 and between 9/10 and 10/10 or 1, we must somehow allow for these. This is done in a very simple way. Why restrict ourselves to 1 figure to the right of the decimal point? For example, on the same principle we could write 1·11 to stand for 1 unit plus 1/10 of a unit plus 1/100 of a unit.

We thus place between 1·1 and 1·2 the following intermediate numbers

1·11, 1·12, 1·13, 1·14, 1·15, 1·16, 1·17, 1·18, 1·19

The jump between successive numbers is now 1/100 or 0·01. Again therefore between two neighbouring numbers such as 1·16 and 1·17 we can insert.

1·161, 1·162, 1·163, 1·164, 1·165, 1·166, 1·167, 1·168, 1·169

Clearly by increasing the number of decimal figures after the point we can make the jump between successive numbers as small a fraction of the original unit as we please.

Here then is a method of filling in the 'space' between any two numbers by as many numbers as we please. We have thus found a number system with tremendous possibilities for expression.

The advantages of the system show themselves at once in the simple processes of addition, subtraction, multiplication and division. The following illustrations will bring this out:

Addition	*Subtraction*	*Multiplication*
17·0350	17·0350	13·9995
4·1781	4·1781	4·1781
13·9995	12·8569	139995
35·2126		1119960
		979965
		139995
		559980
		58·49131095

The multiplication has here been carried through without paying any attention to the decimal point. We know that the result must finally be approximately the same as 4 × 14, i.e. 56. Hence we insert the decimal point after the 8. Otherwise the rule would say that since there are 4 figures after the decimal point in each of the multiples the point must be inserted before the 8th figure from the right in the answer.

Division. To divide 13·9995 by 4·1781

```
4·1781)13·9995(3·35068...
       12 5343
       -------
        1 46520
        1 25343
        -------
          211770
          208905
          ------
           286500
           250686
           ------
            358140
            334248
            ------
             23892
             -----
```

The division proceeds in the usual way. We know that the result must be approximately 3, hence the position of the decimal point is fixed. A series of 0's is brought down in succession, simply because 13·9995 is the same as 13·9995000 . . . The division is carried as far as is required.

Converting Fractions to Decimals. We know already that—

$$\frac{1}{10}=0\cdot1,\ \frac{2}{10}=\frac{1}{5}=0\cdot2,\ \frac{3}{10}=0\cdot3,\ \frac{4}{10}=\frac{2}{5}=0\cdot4,$$
$$\frac{5}{10}=\frac{1}{2}=0\cdot5,\ \frac{6}{10}=\frac{3}{5}=0\cdot6,\ \frac{7}{10}=0\cdot7,\ \frac{8}{10}=\frac{4}{5}=0\cdot8,$$
$$\frac{9}{10}=0\cdot9$$

Other fractions may be expressed as decimals by direct division. Thus:

$$\frac{1}{4}=1\div4=1\cdot00\div4$$
$$=0\cdot25$$
$$\frac{1}{8}=1\cdot000\div8=0\cdot125$$
$$\frac{3}{8}=3\cdot000\div8=0\cdot375$$
$$\frac{5}{8}=5\cdot000\div8=0\cdot625$$
$$\frac{7}{8}=7\cdot000\div8=0\cdot875$$

All the decimals with which we have been so far concerned have consisted of a few numbers after the point, but of course this is not necessary. For example:

$$\frac{1}{3}=1\cdot0000...\div3=0\cdot3333..,\quad\frac{1}{9}=0\cdot1111...,$$
$$\frac{2}{3}=2\cdot0000...\div3=0\cdot6666..,\quad\frac{2}{9}=0\cdot2222...$$

None of these terminate. To indicate this we write a dot above the number that recurs thus:

$$1/9=0\cdot\dot{1}\quad 1/3=0\cdot\dot{3}\quad 2/3=0\cdot\dot{6}$$

Recurring Decimals. A long chain of numbers such as those after a decimal point, all of which are single integers, either show no pattern at all—like

3·14159265 . . .

or recur after a certain interval, such as:

0·142857142857142857142857142 . . .

The former is the ratio of the circumference of a circle to its diameter and does not recur. The latter is the decimal for 1/7 as can easily be found by direct division, 1.0000 . . . ÷ 7. To show how they recur a dot is placed over the first and last digit of the section that repeats. Thus:

$$1/7=0\cdot\dot{1}4285\dot{7}\qquad 2/7=0\cdot\dot{2}8571\dot{4}$$
$$3/7=0\cdot\dot{4}2857\dot{1}\qquad 4/7=0\cdot\dot{5}7142\dot{8}$$
$$5/7=0\cdot\dot{7}1428\dot{5}\qquad 6/7=0\cdot\dot{8}5714\dot{2}$$

To convert a recurring decimal into a fraction:

(1) If a single number recurs after a certain stage then it can be transformed directly. For example:

$$0\cdot125666\ldots = 0\cdot125\dot{6} = 0.125 + 0\cdot000\dot{6}$$
$$= 1/8 + 0\cdot\dot{6}/10000$$
$$= 1/8 + 2/30000$$

(2) If more than one number recurs, for example, $0\cdot161616 = 0\cdot\dot{1}\dot{6}$, add 1/10 of this number to itself then this gives $\frac{11}{10}$ of the correct number. But $0\cdot1\dot{7}$ is $0\cdot1 + 0\cdot0\dot{7} = 1/10 + 7/90$
$= 16/90$

$$\begin{array}{l} 0\cdot16161616\ldots \\ \underline{0\cdot01616161\ldots} \\ 0\cdot17777777\ldots \end{array}$$

$$\text{Thus } 0\cdot\dot{1}\dot{6} = \frac{10}{11} \times \frac{16}{90} = \frac{16}{99}$$

which is simply the recurring portion over a number found by replacing every recurrent term by 9.

$$\text{In the same way } 0\cdot\dot{1}2\dot{5} = \frac{125}{999}$$

$$0\cdot\dot{1}4285\dot{7} = \frac{142857}{999999} = \frac{1}{7}$$

(3) Again consider

$$\cdot014\dot{3}\dot{6} = \cdot014 + \cdot000\dot{3}\dot{6}$$
$$= \frac{14}{1000} + \frac{36}{99000}$$
$$= \frac{14 \times 99}{99000} + \frac{36}{99000} = \frac{1422}{99000}$$

Rounding off a Decimal. Between 1·1 and 1·2 there is no limit to the numbers that can be inserted, those below 1·15 are nearer to 1·1 than those above 1·15. The latter are nearer to 1·2.

Hence if we wish to write such a decimal as 1·13 to one place of decimals we would write it simply as 1·1. In the same way 1·18 to one place of decimals would be written as 1·2. We have *rounded off* the second decimal place.

Example. 1·17832 is
1·1783 to *four* places of decimals,
1·178 to *three* places of decimals,
1·18 to *two* places of decimals and
1·2 to *one* place of decimals.

Finally, the nearest integer is 1.

EXERCISES

Answers appear in the following Lesson.

(1) Write the following decimals as fractions: 21·7, 19·62, 214·03, 70·07, 142·618.
(2) Add together 26·548, 3·006, and 42·71.
(3) Find 4·07295 + 11·20036 − 9·7007.
(4) Subtract 17·3214 from 27·2107.
(5) Multiply 143·65 by 5.
(6) Multiply 16·3074 by 2·14 and confirm that the value is the same as multiplying 2·14 by 16·3074.
(7) Find $\frac{21\cdot4 \times 32\cdot7}{2\cdot6}$
(8) Express the following recurring decimals as fractions: $0\cdot\dot{2}$, $0\cdot\dot{6}$, $0\cdot8\dot{3}$, $2\cdot1\dot{6}$.

Answers to Exercises in Lesson 2

(1) $\frac{1}{4}$, $\frac{3}{4}$, $\frac{1}{5}$, $\frac{14}{19}$ (2) 17, 23, 11.

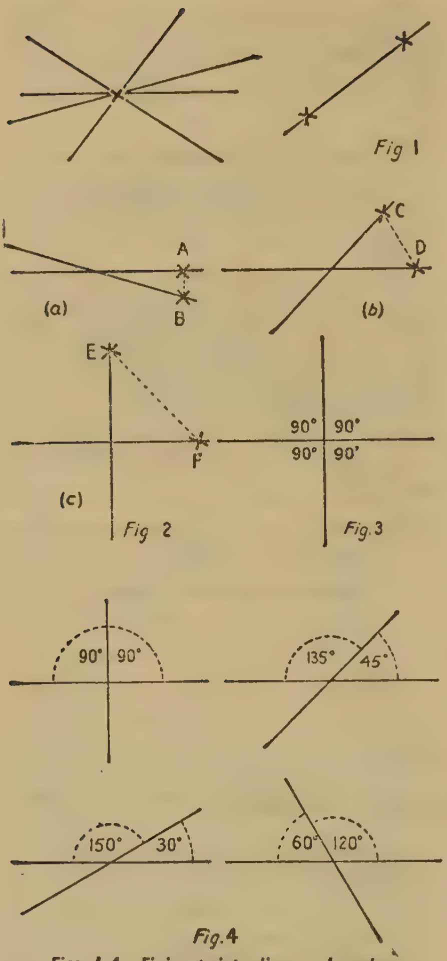
(3) $\frac{167}{264}$ (4) $\frac{41}{48}$ (5) $\frac{113}{180}$

LESSON FOUR

Mathematical Problems of Shape and Size

We have said that science is concerned with the changes that occur in nature, and mathematics with the measurement of these changes. A mathematical problem therefore arises as soon as we have disentangled from a complicated situation those parts of it that relate to shape, size or amount, area, time, etc. This is not always easy to do; for instance, if we are listening to a Beethoven Symphony it is not a simple matter to find a reasonable answer to the question—'*How* beautiful is it?' or 'Does it stir you *more* than it stirs me?' That part of life that is linked up with feelings and emotions has not yet been, if it ever will be, reduced to mathematical form. On the other hand, if we are watching a car speeding round a track we can reasonably ask '*How long* will it take to make a complete circuit?' Or if a house has to be built of bricks, it is obvious that there could be ways and means of discovering the total *number* of bricks required, their total *cost*, their total *weight*, the greatest weight of roofing that can be placed on its walls. All these are questions of a mathematical kind because they involve quantities.

What is a Mathematical Problem? The first step, therefore, in deciding whether a problem is of a mathematical nature is to examine how far it is concerned with shape and size and the changes of these with time. There are other aspects such as force, and temperature, and energy, which fall into the field of physical science, but they also are to that extent mathematical. We shall see later how to analyse a mathematical problem in such a way as to bring our mathematical knowledge to bear on it and solve it. For the moment all we require to recognize is



Figs. 1–4. Fixing points, lines and angles.

that a problem is of a mathematical nature when it is concerned with shapes, sizes, measurements and the relations between these.

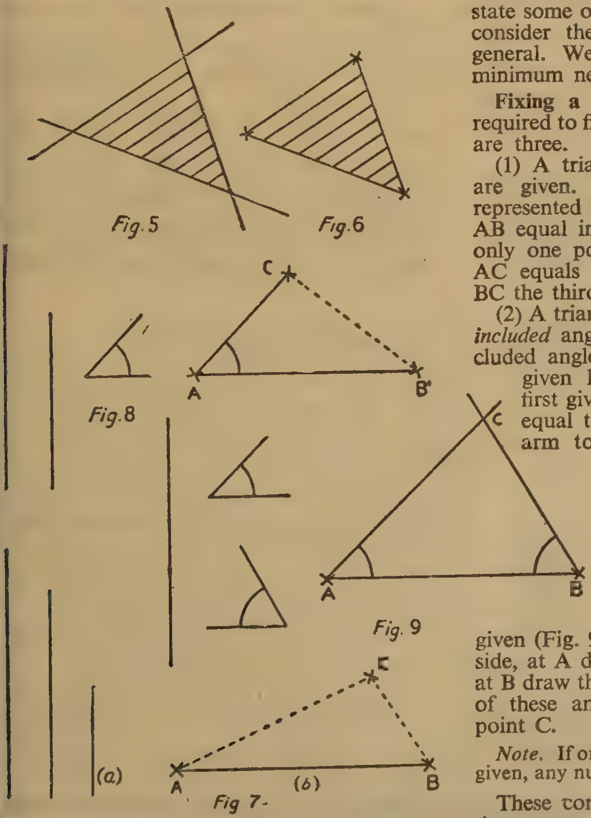
In the Lessons which follow we shall provide ourselves with the mathematical instruments that will enable us to handle such problems, and in doing so we shall see how to disentangle the mathematical side of any complicated situation from those other aspects such as emotions and feelings with which we are not here concerned. It is evident enough that the number of bricks required to build a house of a given shape and size depends on the size and shape of the brick and not on the feelings of the builder. He can be dismissed from the picture. Indeed once the size and shape of the house is given it becomes merely a question of filling up so much space with bricks of certain sizes. Thus the composition of the brick itself also has nothing to do with the question. A mathematical problem is reduced to its proper form when we are left with a statement of what is required in terms of shape and size. We shall return to this later.

Our purpose now is to develop the tools, as we have already produced those of a simple arithmetical nature.

Shapes and Sizes. A mathematical problem is concerned with shape and size, and thus it becomes imperative to consider these terms more exactly. In seeking an answer to the question 'What is a shape?' we shall have to consider points and lines, and an examination of the meaning of size will lead us to discuss lengths, areas and volumes. The branch of mathematics dealing with these problems is termed *Geometry* and the subject divides naturally into two parts, *Plane Geometry* and *Solid Geometry*. Plane geometry deals with points and lines on a *flat surface*, that is to say, the figures that we draw will have width and breadth (and therefore area) but no thickness; while on the other hand solid geometry deals with objects having thickness as well (and therefore volume). In this Lesson we are only concerned with plane geometry.

Points and Lines. Suppose that we have a fixed point (as represented by a dot or a small cross on the paper (Fig. 1)) and wish to draw a straight line through this point. Then since the direction of the line is in no way fixed we can draw any number of lines. If on the other hand we wish to draw a line through two fixed points, then there is only one possibility. Stated otherwise, two points fix a straight line (Fig. 1). Again, if two straight lines cut one another, they fix a point. It may be noticed here that if two lines are drawn which do not cut one another, however far they are drawn in either direction, then those lines are said to be *parallel*.

Angles. If two lines cut one another, this can happen in various ways; for consider the three diagrams (Figs. 2, 3 and 4). Each consists of two lines crossing one another (or *intersecting*, as it is termed in geometry). What differs in the three diagrams is the 'amount of spread,' for consider the distance apart of pairs of points all at the same distance from the points of intersection. These points are lettered A, B; C, D; E, F. Obviously the distance CD is greater than the distance AB, and similarly EF is greater than CD. This ‘ amount of spread ’ between pairs of intersecting straight lines is called the *angle* between them. In the third diagram (Fig. 2*c*) where the four angles made by the lines are all equal, the lines are said to be at *right angles* (Fig. 3), and if each right angle is divided into ninety parts, each small angle so formed is called one *degree* and written 1°. Further for closer measurement of angles each degree may be subdivided into sixty *minutes* (written $60'$), and again each minute split up into sixty *seconds* ($60''$). It may be noticed that in the above the sum of two *adjacent* angles (i.e. two angles next to one another) is 180°, and this is true however the pair of intersecting lines cut, as can readily be seen from Fig. 4.



Figs. 5–9. Fixing sizes and shapes of triangles.

Triangles. So far we have only considered *two* lines intersecting, but suppose we have three lines intersecting, no two of which are parallel. Then each pair will have a point of intersection and we shall have a shape formed by part of each of the three lines; such a shape is called a *triangle* (Fig. 5). Thus a triangle is fixed by three lines or by three points (providing of course that the three points are not in the same straight line).

Every triangle has three sides and three angles (Fig. 6), but these are not all independent, as will be seen later. We have not space here to give detailed geometrical proofs of all the various relations between lines, angles and triangles; these relations (or *theorems* as they are called) may be found in any text book on Geometry. All that we can do is to consider some general properties, state some of the more important facts and consider their bearing on mathematics in general. We shall begin by considering the minimum necessary to fix a triangle.

Fixing a Triangle. The least quantities required to fix the shape and size of a triangle are three.

(1) A triangle is fixed if the three sides are given. Suppose the three sides are represented by three lines (Fig. 7*a*). Draw AB equal in length to the first line. Then only one point C can be found such that AC equals the second line in length and BC the third line (Fig. 7*b*).

(2) A triangle is fixed if two sides and the *included* angle are given (Fig. 8). (The included angle is the angle between the two given lines.) Draw AB equal to the first given line and at A make an angle equal to the given angle extending the arm to the point C and making AC equal the second given side. Then, B and C being now fixed, the third side BC is fixed so that only one triangle can be drawn with the given information.

(3) A triangle is fixed if one side and two of the angles are given (Fig. 9). Draw AB equal to the given side, at A draw one of the given angles and at B draw the other. By extending the arms of these angles they will meet in a fixed point C.

Note. If only the three angles of a triangle are given, any number of triangles may be drawn.

These considerations of the least quantities necessary to fix a *single* triangle have a very important bearing on the relation of *two* triangles to one another; for if two triangles have any one of the above sets of necessary quantities *in common* they must be equal in all respects, since only one distinct triangle can be drawn for each set. Triangles which are equal in all respects are said to be *congruent*.

Finally, then, two triangles will be congruent if they have

(1) Three sides of one equal to the three sides of the other.
(2) Two sides and the included angle of one of the triangles equal to two sides, and the included angle of the other.
(3) Two angles and a corresponding side equal.

Similar Triangles. We have stated above that if only the three angles of a triangle are given, any number of triangles may be drawn. There will, however, be a very important relation between the lengths of the sides of such triangles. Let us discover what this relation is; draw any triangle ABC taking AB equal to, say, two inches and making the angles at B and C a definite number of degrees (Fig. 10*a*). Then draw another triangle DEF making DE equal to, say, 5 inches and having the angles at E and D equal to those at B and A respectively (Fig. 10*b*).

Measure AC, BC, DF, EF. We have made DE two and a half times as long as AB and we shall find that $DF = 2\frac{1}{2} \times AC$ and $EF = 2\frac{1}{2} \times BC$, except for some small practical error. Or in other words we shall find—

$$\frac{DE}{AB} = \frac{5}{2} = \frac{DF}{AC} = \frac{FE}{BC}$$

Indeed this is obvious. The only difference in the two triangles is in the *scale* to which we have drawn the sides; the angles are the same. Such triangles, where the angles are the same and the ratio of corresponding sides equal, are called *similar triangles*.

Facts True about ALL Triangles. (1) Two sides of any triangle are together greater than the third.

A straight line is often defined as the shortest distance between two points and on this definition, the above theorem follows immediately. For suppose ABC is any triangle, then the path from A to B is shorter than the path A to C together with the path C to B (Fig. 11).

$$\text{i.e. } AB < AC + CB$$
$$\text{or } AC + CB > AB$$

(The sign < means 'less than,' and > 'greater than.')

(2) The three angles of any triangle add up to 180°. This may be experimentally verified as follows:

Draw any triangle ABC and through the point A draw a line at right angles to BC (Fig. 12). Call this line AD. Divide AD in two by a line (EF) parallel to BC. Cut the triangle out and fold it about EF. A will coincide with D so that the angle between ED and DF (written ∠ EDF) is equal to A. Again draw lines through E and F parallel

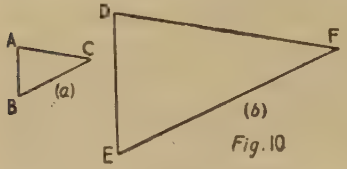


Fig. 10

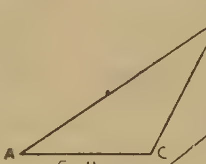


Fig 11

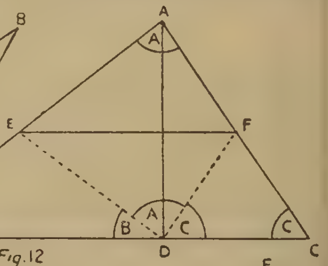
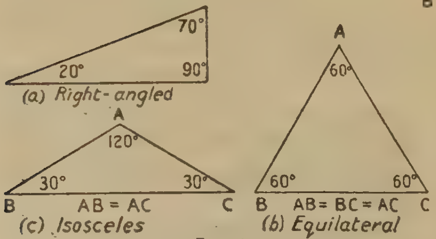


Fig. 12



(a) Right-angled

(c) Isosceles

(b) Equilateral

Fig. 14.

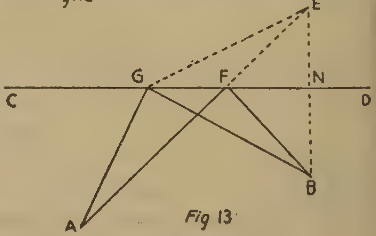


Fig 13

TRIANGLES. Fig. 10. Similar triangles. Fig. 11. Any two sides greater than third. Fig. 12. Three angles total 180°. Fig. 13. Problem. Fig. 14. Particular triangles.

to AD, and fold the triangle about each of these lines in turn. Both B and C will coincide with D, so that ∠ EDB = B and ∠ FDC = C. Finally then since the three angles at D must add up to 180°, BDC being a straight line, we have B + A + C = 180°, i.e. the three angles of a triangle add up to 180°.

Problem. A pilot has to fly from a point A, bomb a straight railway line, and fly back to a point B. It is required to find the direction he must take in order that his total journey shall be as short as possible.

Consider the diagram Fig. 13. A, B represent the starting and finishing points respectively, CD the straight railway line. From B draw a line at right angles to CD cutting it at N and produce to E making NE= BN. Join AE, cutting CD in F. Then AF + FB will be the shortest distance the pilot need fly.

To prove that this is so, take any other point (G) in CD. Join AG, GB and GE. Then we require to show that AG + GB is always greater than AF + FB, wherever G may be.

Since BN = NE by construction, then the triangles FNB, FNE are congruent, i.e. equal in all respects because each of these triangles has two sides equal (FN is common, and BN = NE) and the included angle equal (∠ FNB = 90° = ∠ FNE). Therefore FE = FB. Similarly GE = GB. Thus AF + FB = AF + FE = AE; and AG + GB = AG + GE. Using the property above, that two sides of any triangle are always greater than the third, we have

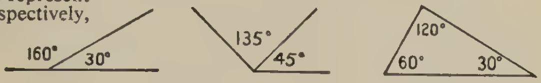
AG + GE > AE

i.e. AG + GB > AF + FB for all positions of G. So that the point F we have found will be the point to bomb the railway line in order that the total distance flown will be a minimum.

Facts True about Particular Triangles. (1) In any right-angled triangle, the sum of the two angles other than the right angle add up to 90°. This follows from the theorem above. Since the three angles of any triangle add up to 180°, then if one angle is 90°, that leaves 90° for the sum of the other two.

(2) In a triangle which has all its sides equal (an *equilateral* triangle) the angles are 60° each. The angles are all equal and therefore any one = 180°/3 = 60°.

(3) An *isosceles* triangle is one which has two of its sides equal in length. The angles opposite these sides are also equal. Fig. 14 illustrates the above three facts.



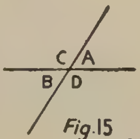


Fig. 15

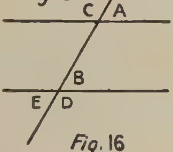


Fig. 16

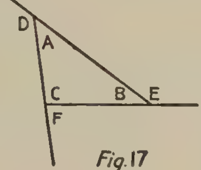


Fig. 17

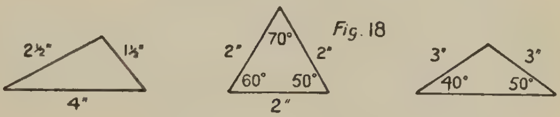


Fig. 18

Figs. 15–18. Exercises on triangles.

EXERCISES

The student will require a semi-circular scale (preferably of celluloid) for measuring angles (called a *protractor*).

(1) Draw any two intersecting lines as shown (Fig. 15). With the protractor measure each of the four angles A, B, C and D. Verify that A = B, C = D, A + C = 180°, A + D = 180°, A + B + C + D = 360°.

(2) Draw two parallel lines. (A convenient method is to place the ruler on the paper and draw lines along both edges.) Draw another line to cut both these parallel lines (Fig. 16). Verify that A = B, C = D, A + D = 180°, C + E = 180°, A = E, A + C + D + E = 360°.

(3) Draw any triangle as shown (Fig. 17). Verify that A + B + C = 180°, D + E + F = 360°, E = A + C, F = A + B, D = B + C.

(4) Draw any triangle ABC. Measure the length of the sides and verify that AB + BC > AC, AB + AC > BC, AC + BC > AB. Draw another triangle DEF having the same angles, making the angles at D and E equal to those at A and B respectively. Measure the lengths of the sides and verify that DE/AB = EF/BC = FD/CA.

(5) Each of the following diagrams (Fig. 18), with the measurements as stated, is incorrect. Without measurement, give reasons for this being so.

Answers to Exercises in Lesson 3

(1) $21\frac{7}{10}$, $19\frac{62}{100}$, $214\frac{3}{100}$, $70\frac{7}{100}$, $142\frac{618}{1000}$
(2) 72·264 (3) 5·57261 (4) 9·8893
(5) 718·25 (6) 34·897836
(7) 269·14615384... (8) $\frac{2}{9}$, $\frac{2}{3}$, $\frac{5}{6}$, $2\frac{1}{6}$

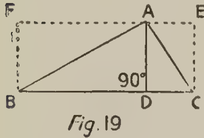
LESSON FIVE

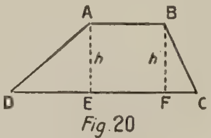
Areas Enclosed by Simple Shapes

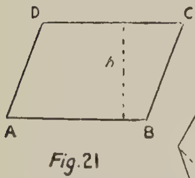
One of the most important facts concerning any shape is the area it encloses. We will now consider the areas of triangles and of some other simple plane figures.

Rectangle. A rectangle is a four-sided figure, all the angles of which are right angles; its opposite sides are equal and thus its area is equal to the length of one side multiplied by the length of an adjoining side. If the sides are measured in inches, the area will be expressed in *square inches*.

Triangle. The area of any triangle is equal to one half the length of any side multiplied by the length of a line drawn from the opposite angular point (or *vertex*) at right angles to that side. (This line is called a *perpendicular*.) Thus in Fig. 19 the area of the triangle ABC $= \frac{1}{2}$.BC.AD. This follows very simply from the expression for the area of the rectangle. Suppose a rectangle BCEF be drawn with BC as one side, and the adjoining side made equal to AD. Then the area of the right-angled triangle ADB is half the area of the rectangle ADBF. Similarly area $\triangle$ ADC $= \frac{1}{2}$ area rectangle ADCE. By adding, therefore, the area of the $\triangle$ ABC $= \frac{1}{2}$ (rect. ADBF + rect. ADCE) $= \frac{1}{2}$ rect. BCEF $= \frac{1}{2}$. BC . AD.







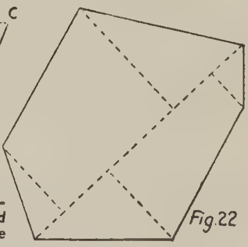


Fig. 19–22. Areas enclosed by triangles and other simple plane figures.

Trapezium. Any four-sided figure is called a *quadrilateral*. A *trapezium* is a particular quadrilateral with two sides parallel. Its area is found as follows: If ABCD represents the trapezium (Fig. 20), draw perpendiculars AE and BF from A and B, to CD. Since AB and CD are parallel, AE = BF. Suppose that each of these lines is h units in length, then the area of the trapezium—

$$= \text{area rect. ABFE} + \text{area} \triangle \text{AED} + \text{area} \triangle \text{BFC}$$

$$= h.\text{EF} + \tfrac{1}{2}.h.\text{DE} + \tfrac{1}{2}.h.\text{FC}$$

$$= h\left(\text{EF} + \frac{\text{DE}}{2} + \frac{\text{FC}}{2}\right)$$

$$= \frac{h}{2}(2\text{EF} + \text{DE} + \text{FC})$$

$$= \frac{h}{2}(\text{EF} + \text{EF} + \text{DE} + \text{FC})$$

$$= \frac{h}{2}(\text{EF} + \text{CD}) \text{ since CD} = \text{DE} + \text{EF} + \text{FC}$$

i.e. the area of a trapezium is equal to half the sum of the parallel sides multiplied by the distance between them.

Parallelogram. A quadrilateral which has two pairs of parallel sides is called a parallelogram (Fig. 21). Its opposite sides are equal in length, i.e. AB = CD and CB = AD and since it is also a trapezium its area is:

$$\tfrac{1}{2} \times h \times (\text{AB} + \text{CD}) = \tfrac{1}{2} \times h \times 2 \times \text{AB}$$

$$= h \times \text{AB}$$

The diagonals of a parallelogram *bisect* each other, i.e. each diagonal passes through the mid-point of the other.

Any Polygon. Every polygon can be divided into a number of triangles and trapezia as indicated in Fig. 22, by drawing a line right across the figure from one vertex to another and drawing perpendiculars to this line from all other angular points.

Theorem of Pythagoras. This is one of the most important theorems in geometry and is supposed to have been discovered by the Greek philosopher Pythagoras (born about 530 B.C.). The theorem states that in any right-angled triangle (Fig. 23) the square drawn on the longest side (called the *hypotenuse*) is equal in area to the sum of the squares on the other two sides, i.e.:

sq. BCDE = sq. ACIH + sq. ABFG,
or, alternatively,
$(\text{BC})^2 = (\text{AC})^2 + (\text{AB})^2$.

Where no confusion can arise this may, for convenience, be written

$$BC^2 = AC^2 + AB^2.$$

Thus, as an example, if AC = 3 inches, AB = 4 inches; then—

$$\begin{aligned} BC^2 &= 3^2 + 4^2 \text{ sq. inches} \\ \text{i.e. } BC^2 &= 9 + 16 \text{ sq. inches} \\ &= 25 \text{ sq. inches} \\ \text{i.e. } BC &= 5 \text{ inches.} \end{aligned}$$

The truth of this theorem can be seen in many ways, one of the simplest being by the use of similar triangles. Let ABC (Fig. 24) be any right-angled triangle having the right angle at A. From A draw a perpendicular AD on to the hypotenuse. Then, first of all, the △ ABD is similar to the △ ABC because they are both right-angled triangles and have the angle B in common. Therefore:

$$\frac{AB}{BC} = \frac{BD}{AB} \text{ or } AB^2 = BC \times BD.$$

Again, the triangles ADC, ABC are similar; they are both right-angled and have the angle C in common. Thus:

$$\frac{AC}{CD} = \frac{BC}{AC} \text{ or } AC^2 = BC \times CD$$

Adding these two relations together

$$\begin{aligned} AB^2 + AC^2 &= BC \times BD + BC \times CD \\ &= BC\,(BD + CD) \\ &= BC \times BC \\ &= BC^2 \end{aligned}$$

Problem. A ladder 26 ft. long just reaches to the eaves of a house when the foot of the ladder is 10 ft. away from the house wall (Fig. 25). What is the height of the eaves above the ground? Suppose that h feet represent the height of the eaves above the ground. Then from the theorem above

$$\begin{aligned} h^2 + 10^2 &= 26^2 \\ \text{or } h^2 &= 26^2 - 10^2 \\ h^2 &= 676 - 100 = 576 \end{aligned}$$

so that h = 24 feet.

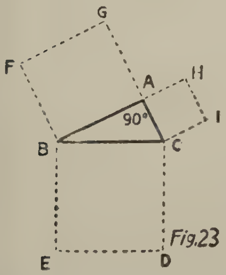


Fig.23

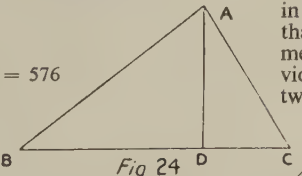


Fig 24

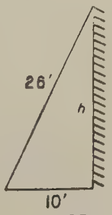


Fig. 25

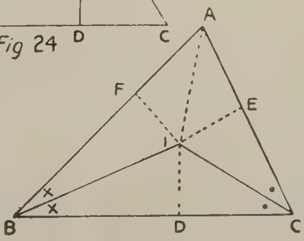


Fig 26

Figs. 23–25. Theorem of Pythagoras with proof and application. Fig. 26. Concurrent lines in a triangle.

Theorems on Triangles. In the geometrical work we have done so far, we have considered the fundamental facts concerning triangles but there still remain several theorems that are of importance in branches of applied mathematics. We will consider these now.

(1) The straight lines which bisect the angles of a triangle are concurrent.

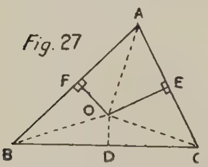
(Three or more lines are said to be *concurrent* if they all pass through one point.)

Let ABC be any triangle (Fig. 26) and suppose that the angles at B and C are bisected by two lines meeting in I. From I draw perpendiculars to the sides, meeting them in D, E, F as shown, and join IA. If we can show that IA bisects the angle at A then we will have shown that the three bisectors of the angles of a triangle all pass through the same point.

The proof is very simple: since BI bisects the angle at B, △ IBD equals △ IBF, (indicated on the diagram by a small cross). In addition, the triangles BID and BIF are right-angled and have the hypotenuse (BI) in common. Thus they are congruent and ID = IF. By applying exactly similar reasoning to the triangles CID and CIE we have ID = IE, so that IF = IE, which proves that the right-angled triangles AIF, AIE are congruent, i.e. ∠ FAI = ∠ EAI, or AI bisects the angle at A. (It is important to notice that since IF = ID = IE, a circle with centre I could be drawn to pass through E, F and D.)

(2) The straight lines which bisect the sides of a triangle at right angles are concurrent.

Let ABC be any triangle (Fig. 27) and D, E, F the mid-points of the sides. Through F and E draw perpendiculars meeting in O. Join OD. We require to prove that OD is at right angles to BC. The method of proof is similar to the previous; the triangles AFO, BFO have two sides and the included angle equal, and are therefore congruent, so that OB = OA. Similarly OA = OC and consequently OB = OC. Now D is the mid-point of BC by construction, so that the triangles ODB, ODC have two sides equal and the third side common. Thus the triangles are congruent and therefore ∠ ODB = ∠ ODC, i.e., they are each right angles. O is thus the point of intersection of the three perpendicular bisectors of the sides of the triangle. (It should be noticed that, since OA = OB = OC, a circle with centre O will pass through the point A, B, C. This circle is called the *circumscribed* circle of the triangle ABC.)



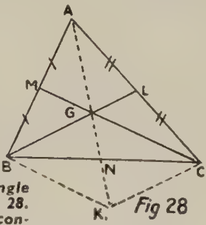


Fig. 27. Lines bisecting triangle sides are concurrent. Fig. 28. Medians of a triangle are concurrent.

(3) The *medians* of a triangle are concurrent. (A *median* of a triangle is a straight line drawn from an angular point to the mid-point of the opposite side.)

Let ABC be any triangle and BL, CM two medians meeting in G (Fig. 28). Join AG and continue this line until a point K is reached where GK = AG. Let this line cut the side BC in N.

We have to prove that AN is a median, i.e. that BN = CN. Join BK and CK. By our construction we have made G the mid-point of AK, and L the mid-point of AC. Therefore GL is parallel to KC, i.e. BL is parallel to KC. Similarly CM is parallel to BK so that we have proved that the quadrilateral BKCG is a parallelogram. Now one of the properties of a parallelogram is that its diagonals bisect each other, i.e. BN = NC and GN = NK.

The first of these relations proves our theorem because it shows that AN is a median and therefore the three medians are concurrent. The second of the relations fixes the position of G because GN = NK, i.e. GN is one half of GK, i.e. GN is one half of AG, i.e. GN is one third of AN so that the point of intersection of the medians is one third the way up either, or, stated otherwise, G is a point of *trisection* of a median.

This geometrical theorem is of very great importance in connexion with problems on centres of gravity in mechanics (*see* Mechanics, Vol. IV, Lesson 9, page 179).

EXERCISES

(1) Draw a triangle having sides 4, 6 and 8 inches in length. Draw and measure the three perpendiculars from the angular points on to the opposite sides. Find the area of the triangle three ways by using each perpendicular in turn.

(2) Find the area of the figure, having the lengths (in feet) as shown (Fig. 29).

(3) Draw a straight line AE 4 inches in length making AB = BC = CD = DE = 1 inch. Through the end A, draw a perpendicular line AP, one inch in length. Join PB, PC, PD, PE. Verify that these lengths will represent $\sqrt{2}$, $\sqrt{5}$, $\sqrt{10}$, $\sqrt{17}$ respectively and find them by measurement.

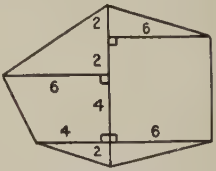


Fig. 29

(4) Draw three triangles having sides of lengths 5, 12, 13 cms.; 8, 15, 17 cms.; 12, 35, 37 cms. By measuring the angles verify that they are right-angled triangles. Use the theorem of Pythagoras to confirm by calculation.

(5) A triangle ABC has sides AB = $2\frac{1}{2}$ inches, BC = $6\frac{1}{2}$ inches and AC = 6 inches. Verify by drawing that it is a right-angled triangle and confirm by calculation. Use a protractor to draw a perpendicular (AD) from A on to BC. From similar triangles calculate the lengths of AD, BD and CD.

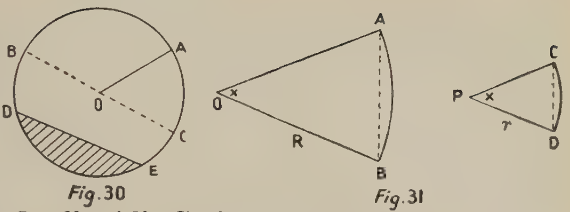
Answer to Exercise in Lesson 4

(5) (*a*) Angles do not add up to 180°; (*b*) angles add up to 180°, but should not; (*c*) angles do not add up to 180°; (*d*) two sides are not greater than the third; (*e*) angles of an equilateral triangle are equal; (*f*) angles at the base of an isosceles triangle are equal.

LESSON SIX

Circles

In earlier Lessons we have restricted attention to shapes composed of straight lines. The smallest number of such lines that could enclose a space is three, giving a triangle. In this Lesson we give up the restriction that the elements of which the shape is composed are *straight* lines. In that case a space can be enclosed by a *closed* curved line, of oval or circular shape. Shortly we shall give a precise definition of these terms. For the moment it should be noticed that such shapes are of great importance in all forms of mechanism, the simplest of which is, of course, the wheel. Because the use of the tree-trunk, the rolling log and the wheel as an aid to transport date from antiquity, it is not surprising that the properties of closed figures such as circles have been the subject of study for many thousands of years. The accuracy of such knowledge can be seen if, for example, we study the specifications given in the Bible for the building of the Temple. The Hebrews, the Egyptians and the Greeks all in their time made their contributions to the development of the subject.



Figs. 30 and 31. Chords, segments, sectors and arcs of circles. Calculating the circumference.

Here then we are concerned with shapes that are bounded by circles and straight lines.

Circles. A circle is defined as the figure enclosed by a curve traced out by a point which is always a fixed distance from a fixed point. The fixed point is called the centre of the circle, the fixed distance is the *radius*, and the curved path the *circumference*. Any line passing through the centre and terminated by the circumference is called a *diameter*, so that the length of a diameter is twice that of the radius. In Fig. 30 OA is a radius, BC a diameter. Any other line, such as DE, which divides the circle into two parts is a *chord* and the two parts (one of which is shaded) are called *segments*. Also, any part of a circle bounded by two radii and part of the circumference (such as the shape OAC) is a *sector*, the curved part of the circumference, AC, being termed an *arc*.

Circumference of a Circle. One of the fundamental properties of the circle is that the circumference divided by the diameter is a constant, quite independent of the size of the circle, and this theorem may be expected from our knowledge of similar triangles. Consider two sectors of different circles, both sectors having the same angle at the centre (Fig. 31). Let the sectors be OAB and PCD and draw the chords AB and CD. Suppose the radius of one circle is R units and of the other, r; then because OAB and PCD are similar triangles AB/R = CD/r. From this it follows, as is to be expected, that

$$\frac{\text{arc AB}}{\text{R}} = \frac{\text{arc CD}}{r}$$

and the number which, multiplied by the arc AB, gives the circumference of the circle with centre O, will be the same as that which, when multiplied by the arc CD, gives the circumference of the circle with centre P, because the angles AOB and CPD are equal. Thus, finally the circumference divided by the radius is a constant for all circles; or, since the diameter is twice the radius, we have

$$\frac{\text{circumference}}{\text{diameter}} = \text{constant.}$$

This constant has been denoted for centuries by the Greek letter π; it is a non-terminating non-recurrent decimal, its value to 5 places of decimals is 3·14159 . . . . Finally we may write:

$$\begin{aligned}\text{Circumference of any circle} \\ &= \pi \times \text{its diameter} \\ &= 2 \times \pi \times \text{its radius.}\end{aligned}$$

Area of a Circle. We may deduce the area of a circle in the following way. Let any circle be drawn and divided up into an even number of sectors and suppose these sectors are placed side by side as shown in Fig. 32. Then by increasing the number of sectors the diagram above will eventually become a parallelogram, its area being AB × AC. Now AB, which will finally become a straight line, must be half the circumference in length since it is made up of the arcs of half the total number of sectors. Also AC is the radius of the circle (R). The area of the final parallelogram (which will be the area of the circle) will be R × πR = πR^2.

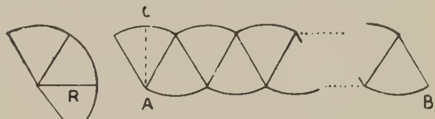


Fig. 32. Calculating the area of a circle.

Measurement of Angles. From the fact that the circumference of any circle divided by its radius is a constant, we have another method of measuring angles which is suitable for special branches of mathematical work. Draw any circle, and suppose that the length of an arc AB is made equal to the radius OA (or OB)

(Fig. 33). Then the angle BOA will be the same whatever the size of the circle and is therefore conveniently taken as a unit angle. This angle is called a *radian*, and consequently may be defined as the angle subtended at the centre of a circle by an arc equal in length to the radius. Since we already have one method of measuring angles (i.e. degrees) there must be a relation between degrees and radians. From Fig. 33 one radian must be nearly equal to 60° since the *arc* AB is not very different in length from the *chord* AB.

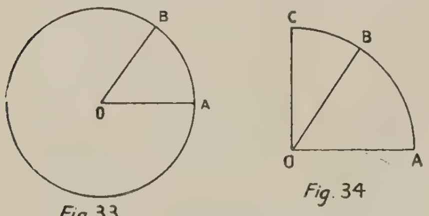


Fig. 33 *Fig.* 34

Figs. 33 and 34. Relation between degrees and radians.

However, we can find the exact relation quite easily. Consider a quadrant of a circle (Fig. 34) and draw an angle of 1 radian, let the radius of the circle be R units. Then by definition of a radian, the arc AB = R units in length. Also the arc AC, being one quarter of the circumference of the circle, is $\frac{1}{4} \times 2 \times \pi \times R$ units in length, and the angle COA = 90°.

$$\text{Thus} \qquad \frac{\angle \text{BOA}}{\angle \text{COA}} = \frac{\text{arc AB}}{\text{arc AC}}$$

$$\text{So that} \qquad \frac{1 \text{ radian}}{90^\circ} = \frac{\text{R}}{\pi\text{R}/2} = \frac{2}{\pi}$$

Cross multiplying

$$\begin{aligned} \pi \text{ radians} &= 180 \text{ degrees,} \\ \text{i.e. } 3{\cdot}141592 \text{ radians} &= 180 \text{ degrees,} \\ \text{and therefore } 1 \text{ radian} &= 57{\cdot}296 \text{ degrees.} \end{aligned}$$

We append a table giving the relation between degrees and radians for some of the commoner angles:

$30^\circ = \pi/6$ $(=0{\cdot}5236)$ radians
$45^\circ = \pi/4$ $(=0{\cdot}7854)$ radians
$60^\circ = \pi/3$ $(=1{\cdot}0472)$ radians
$90^\circ = \pi/2$ $(=1{\cdot}5708)$ radians
$180^\circ = \pi$ $(=3{\cdot}1416)$ radians
$360^\circ = 2\pi$ $(=6{\cdot}2832)$ radians

Length of a Circular Arc. One of the advantages of measuring angles in radians is that it enables us to obtain a very simple expression for the length of any circular arc. Consider Fig. 35: it consists of any arc (AB) of a circle of radius r units together with an arc AC which has been made equal to the radius, so that the $\angle$AOC = 1 radian by definition. Since the ratio of the lengths of two arcs of the same circle is the same as the ratio of the angles which each arc subtends at the centre of the circle

$$\frac{\text{arc AB}}{\text{arc AC}} = \frac{\angle \text{AOB}}{\angle \text{AOC}}$$

$$\text{i.e.} \qquad \frac{\text{arc AB}}{r} = \frac{\angle \text{AOB (in radians)}}{\angle \text{AOC (in radians)}} = \frac{\angle \text{AOB (in radians)}}{1}$$

$$\text{Thus} \qquad \text{arc AB} = r \times \angle \text{AOB (in radians).}$$

We can now check our previous expression for the circumference of a circle. The angle at the centre of a circle is four right angles, i.e. 360° or 2π radians; therefore the length of the circumference $= r \times 2\pi$, which is the value already obtained.

Area of a Sector of a Circle. Referring again to Fig. 35 we may find the area of the sector AOB by the same method as that for finding the area of the circle earlier in this Lesson. There, we divided the circle into an even number of sectors and placed them end to end (Fig. 32). We may divide the sector AOB into an even number of smaller sectors placed end to end, when we shall obtain, by increasing the number of small sectors, a parallelogram having one side of length ($\frac{1}{2}$ arc AB), and the radius of the circle (r) as the perpendicular length between the parallel sides. Thus

$$\begin{aligned} &\text{area of sector AOB (Fig. 35)} \\ &= r \times \tfrac{1}{2} \text{ arc AB} \\ &= r \times \tfrac{1}{2} \times r \times \angle \text{AOB (in radians)} \end{aligned}$$

from the theorem above giving the length of a circular arc,

$$= \tfrac{1}{2} r^2 \times \angle \text{AOB (in radians).}$$

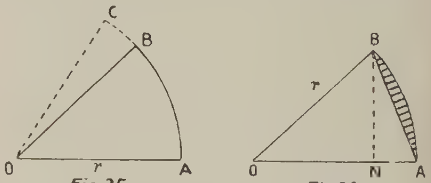


*Fig.*35 *Fig.*36

Figs. 35 and 36. Areas of sectors and segments of a circle.

Area of a Segment of a Circle. The area of the segment, shaded in the diagram (Fig. 36), is obviously the area of the triangle AOB subtracted from the area of the sector AOB, i.e.

area of segment = area of sector AOB − area △ AOB $= \frac{1}{2} r^2 \times \angle AOB - \frac{1}{2} r \times BN$, where BN is the perpendicular from B on to OA.

We have not yet sufficient knowledge to obtain an expression for the length of BN in terms of the ∠AOB. We shall return to this in Lesson 9.

Theorems on Circles. We give now a list of the more important facts concerning circles. We will indicate why the results are to be expected and how they are obtained, but for a rigorous proof the reader is referred to a text-book on geometry.

(1) *The line drawn from the centre of a circle to bisect a chord is perpendicular to it.* If AB is the chord (Fig. 37), C its midpoint and O the centre of the circle, then the triangles OAC, OBC are congruen because OA = OB = radius, AC = CB, and OC is common to both triangles. Therefore ∠OCA = ∠OCB = 90°.

Note. A *tangent* to a circle is a line which touches the circle and when produced does not cut it. Let CD represent a line (Fig. 38) cutting the circle in P and Q, and suppose that P is kept fixed, and CD is revolved about P so that Q approaches P. Then ultimately Q and P will become the same point and the line CD will lie along AB. This line (AB) is then a tangent to the circle at the point P, which is said to be the *point of contact.*

(2) *A tangent to a circle is at right angles to the radius drawn to its point of contact.* In Fig.38 ∠OPA = ∠ OPB = 90°. Important results of this theorem are that:

(a) only one tangent to a circle can be drawn through a given point on the circumference, and

(b) the straight line at right angles to a tangent, at its point of contact, passes through the centre of the circle.

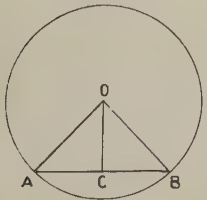


Fig. 37

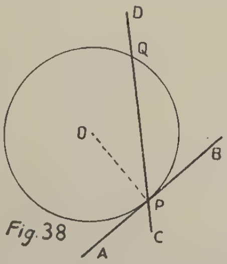


Fig. 38

THEOREMS ON CIRCLES. Fig. 37. Bisecting a chord. Fig. 38. A tangent to a circle is at right angles to the radius.

(3) *The two tangents drawn to a circle from a point outside it are of the same length.* Let PS and PT be the tangents drawn from a point P to the circle, centre O (Fig. 39). The triangles OPS, OPT are congruent because they are both right-angled, OS = OT, and OP is common. Thus PS = PT.

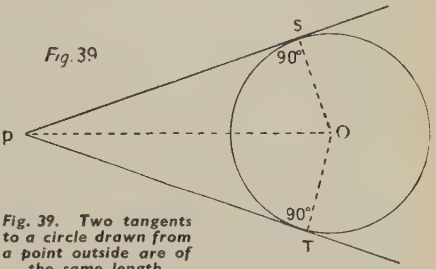


Fig. 39. Two tangents to a circle drawn from a point outside are of the same length.

(4) *The angle at the centre of a circle is double the angle at the circumference standing on the same arc.* Let AB be the arc (Fig. 40), O the centre of the circle so that ∠AOB is the angle at the centre, and let C be any point on the circumference. Then ∠ACB is the angle at the circumference and we have to show that ∠AOB = 2 × ∠ACB. Join CO and produce to D. Then the triangle OAC is isosceles (OC equalling OA) and therefore ∠OAC = ∠OCA. Also, in Lesson 4, we saw tha the exterior angle of any triangle equals the sum of the two interior opposite angles (A=B+C, Fig. 41) so that finally (Fig. 40):

∠DOA = ∠OAC + ∠OCA = 2 × ∠OCA
Similarly
∠DOB = ∠OBC + ∠OCB = 2 × ∠OCB
Adding, ∠AOB = 2 × ∠ACB.

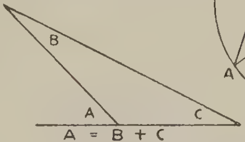


Fig. 41

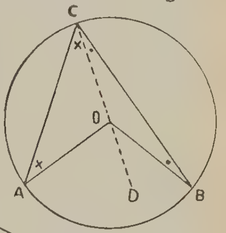


Fig. 40

THEOREMS ON CIRCLES. Figs. 40, 41. Angles at the centre of a circle.

(5) *Angles in the same segment of a circle are equal.* This follows immediately

from the theorem above; since C was any point on the circumference, every angle at the circumference is half the angle at the centre and therefore all angles in the same segment are equal (Fig. 42).

(6) *The opposite angles of a quadrilateral which is drawn within a circle so that the four corners lie on the circumference are together equal to two right angles.* (This is said to be a *cyclic* quadrilateral.)

This theorem follows from (4) above. If ABCD represents the cyclic quadrilateral (Fig. 43) and if O denotes the centre of the circle, join DO, BO. Then the smaller angle DOB (i.e. less than 180°) equals twice the angle at C and the larger angle DOB (i.e. greater than 180°, sometimes called the *reflex* angle DOB) equals twice the angle at A, as indicated in the diagram. But these two angles DOB together add up to four right angles. Thus $2A + 2C = 360°$, or $A + C = 180°$, so that the opposite angles of a cyclic quadrilateral add up to two right angles.

NOTE. In this theorem the quadrilateral was cyclic, and we had to prove that the opposite angles added up to 180°. If we had proved that if the opposite angles of a quadrilateral added up to 180°, then the quadrilateral was cyclic, we should have been proving the *converse* theorem. In this case the converse is also true, but often the converse of a statement is untrue, for instance—'all dogs have two eyes' is a true statement, but the converse, that all animals which have two eyes are dogs, is obviously false.

(7) *The angle in a semicircle is a right angle.*

Let AB be a diameter of a circle (Fig. 44), centre O, and C any point on the circumference; we have to prove that $\angle ACB = 90°$. Join CO, and obtain two isosceles triangles, AOC and BOC. Therefore $\angle OAC = \angle OCA = A$ and $\angle OBC = \angle OCB = B$. Since the angles of a triangle add up to 180° we have

$$\angle OAC + \angle OCA + \angle OBC + \angle OCB = 180°,$$

or

$$2A + 2B = 180°,$$

i.e.

$$A + B = 90°,$$

so that $\angle ACB$ is a right angle.

(8) *The angle between a tangent and the chord through the point of contact is equal to the angle in the opposite segment.*

Consider Fig. 45. AB is a tangent to the circle, centre O, P being the point of contact and PQ is a chord. PC is a diameter and we have to prove that $\angle BPQ = \angle PCQ$. The proof is as follows: $\angle CQP = 90°$ because it is the angle in a semicircle and therefore $\angle CPQ = 90° - \angle PCQ$. But $\angle CPQ$ also equals $90° - \angle BPQ$, since OP is perpendicular to the tangent AB (see theorem (2) above). Therefore $\angle BPQ = \angle PCQ$.

EXERCISES

(1) A square is drawn inside a circle of radius 2 in., so that each corner lies on the circumference of the circle. Thus four segments are formed. Find the areas of the circle, the square, and each segment.

(2) Which is the greater angle, 120° or 2·1 radians?

(3) Draw a sector of a circle of radius 4 in., having an angle of 50° at the centre. Fix about 20 pins round the arc and find an approximation to the length of the arc with a piece of cotton. Convert 50° to radians and calculate the length of the arc accurately and also the area of the sector.

(4) Draw any circle together with two intersecting tangents. Measure the lengths of the two tangents from the point of intersection to the points of contact and verify that they are the same within the limits of practical error.

(5) Draw any circle, centre O, and any chord PQ. Join PQ to O and to any three points A, B, C in the same segment as the centre. Verify, by measurement, that $\angle PAQ = \angle PBQ = \angle PCQ = \frac{1}{2} \angle POQ$.

(6) Draw a circle and any cyclic quadrilateral. Verify that the sum of each pair of opposite angles is 180°.

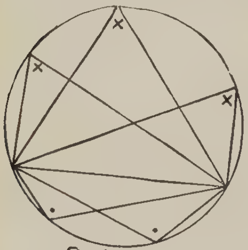


Fig. 42

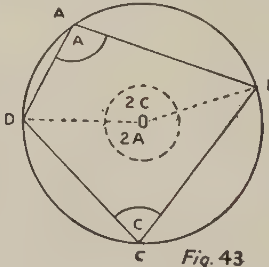


Fig. 43

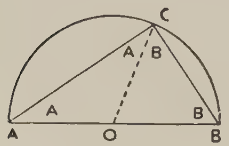


Fig. 44

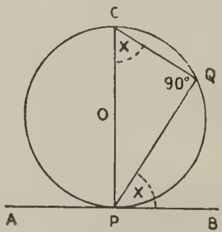


Fig. 45

Fig. 42. Angles in same segment. Fig. 43. Cyclic quadrilateral. Fig. 44. Angle in a semicircle. Fig. 45. Angle between a tangent and a chord.

(7) A tangent is drawn to a circle from a point P, T being the point of contact. Another line is drawn through P, cutting the circle in A and B. Prove that the triangles PAT, PTB are similar, and hence that PA × PB = PT². Verify by drawing and measuring a particular case.

Answers to Exercises in Lesson 5

(1) Area = 11·62 sq. in.

(2) 84 sq. ft.

(3) 1·41, 2·26, 3·16, 4·12.

(5) AD = 2·31 in., BD = 0·96 in., CD = 5·54 in.

LESSON SEVEN

Practical Geometry

In the two previous Lessons we have been studying plane geometry—the properties of points, lines, triangles, circles on a flat surface; and frequently it was necessary, in order to prove some important fact concerning these figures, to imagine that some piece of construction had been carried through. Thus, for example, in one theorem we supposed that the bisector of an angle had been drawn; in another, the bisector of a line, and, again, we frequently assumed that a line perpendicular to the side of a triangle had been constructed. This was quite reasonable, but it is very important not to lose sight of the practical aspect.

Practical Geometrical Technique. We must be prepared, if we are to develop the subject logically, to supply answers to such questions as '*How* do you bisect an angle?' or '*How* do you draw a perpendicular?' and to supply those answers in a practical way with a pencil, a ruler and a pair of compasses. It is the technique of this practical geometry that we will now consider.

(1) *To bisect a given angle* (Fig. 46). Let A be the point of intersection of the lines forming the angle; then with compass point on A draw an arc of a circle with any radius to cut the lines in B and C. With compass point first at B and then at C draw arcs with any, but the *same*, radius to cut at D. Join AD, which is the bisector of the given angle. The proof is simply that, in the triangles ABD and ACD, AB = AC, BD = CD, and AD is common, so that these triangles are congruent, i.e. ∠CAD = ∠BAD.

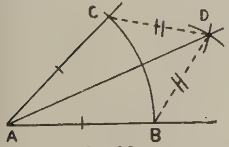


Fig. 46

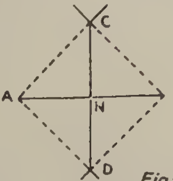


Fig. 47

Fig. 46. How to bisect a given angle. Fig. 47. How to bisect a given straight line.

(2) *To bisect a given straight line.* Let AB be the given straight line. With centre first at A and then at B and any radius draw two arcs to intersect above the line in C and two arcs to intersect below the line in D. CD is the perpendicular bisector of AB at N (Fig. 47).

The proof is as follows: Join AC, BC, AD, BD; these will all be equal since they are the radii of the same or equal circles. Thus the triangles CAD, CBD are isosceles with two sides of one equal to two sides of the other and the side CD common to both. Therefore these triangles are congruent and ∠ACD = ∠BCD. Therefore if CD cuts AB in N, the triangles ACN, BCN are congruent because AC = BC, CN is common, and the included angle ACN equals the included angle BCN. Thus AN = BN and ∠CNA = ∠CNB = 90°, i.e. CD is the perpendicular bisector of AB.

(3) *To draw a perpendicular to a given straight line from a given point outside it.* Let AB be the given straight line and C the point from which a perpendicular is to be drawn. With centre C draw any arc to cut AB in D and E and with these points as centres and the same radius draw arcs to cut in F (Fig. 48). CF is the perpendicular required. By joining CD, CE, FD and FE the proof follows exactly the same reasoning as in case (2) for the bisection of a given line and we leave it as an exercise for the student.

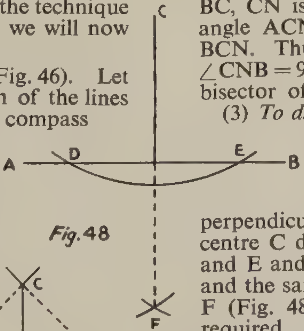
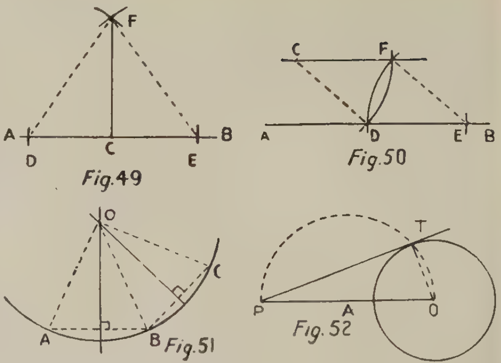


Fig. 48

(4) *To draw a perpendicular to a given straight line from a given point in it.* Let AB be the given line and C the given point

(Fig. 49). We have to draw a perpendicular to AB at C. With centre C and any radius, draw arcs cutting AB in D and E. With these points as centres and radius greater than DC, draw arcs cutting in F. FC is the perpendicular required. The proof is this: join FD and FE, then the triangles FCD, FCE are congruent because FD = FE, CD = CE and CF is common. Therefore ∠FCD = ∠FCE = 90°.



CIRCLES. Fig. 49. Drawing a perpendicular. Fig. 50. Drawing a line parallel to a given line. Fig. 51. Describing a circle through three points. Fig. 52. Tangent to a circle from a point outside.

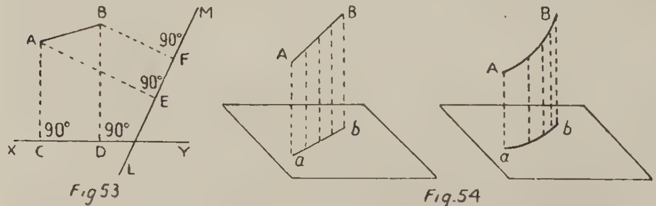
(5) *To draw a straight line through a given point parallel to a given straight line.* Let AB be the given line, C the given point (Fig. 50). We require a line through C parallel to AB. With centre C and any radius sufficient to cut AB, draw an arc as shown in the diagram, cutting AB in D. With D as centre and the same radius draw another arc to cut AB in E. With centre E and the same radius draw an arc which must cut the first arc in D and another point F. CF is parallel to AB. The proof is that CD = CF = DE = EF and so CFED is a parallelogram, i.e. CF is parallel to AB.

(6) *To draw a circle through three given points* (*not in the same straight line*). Let A B and C be the three points. Join AB, BC. These will be chords of the required circle. Bisect AB and BC at right angles (see (2) above) and let these bisectors intersect in O. Then O is the centre of the required circle and OA (= OB = OC) is the required radius (Fig. 51). The proof of the above construction we leave as an exercise to the reader.

(7) *To draw a tangent to a given circle from a point outside it.* Let P be the given point, and O the centre of the given circle. Join OP. Bisect OP in A and, with this point as centre, draw a semicircle cutting the original circle at T. Join PT. It is a tangent to the given circle because ∠PTO = 90° as it is the angle in a semicircle. Therefore OT is at right angles to PT and OT is a radius of the circle. Therefore PT is a tangent (Fig. 52).

Projection. A very important idea in mathematical work is that of *projection.* Consider a line (AB) of fixed length and suppose that perpendiculars are drawn from A and B on to another line XY, the feet of the perpendiculars being C, D respectively. Then CD is said to be the projection of AB on the line XY. Similarly EF is the projection of AB on to another fixed line LM (Fig. 53).

Some of the uses of these projections will be considered in later Lessons, but we may notice here that the idea of projection need not be confined to plane geometry as in the above. For instance, suppose we have any line (AB) straight or curved in space, and from every point in such a line we draw perpendiculars on to some plane (or flat) surface. We shall obtain the projection of the line on the plane. Such projections are represented by the lines *ab* (Fig. 54). It is this idea of the projection of lines in space on to planes which forms the basis of the technical drawing and 'blue print' of the engineer.



PROJECTION. Fig. 53. Projecting line AB on to lines XY and LM. Fig. 54. Projecting line AB on to a plane. Fig. 54. Curved line on to plane.

Technical Drawing. In engineering, the facts about a piece of machinery which has been made, or which it is proposed to make, have to be conveyed from one person to another, and while a picture is useful for showing the *shape* of the object it is generally useless as a means for giving the *size* of the object. Obviously, the actual measurements of each part of the solid body are of extreme importance, so that diagrams have to be devised to give this information. A difficulty arises immediately. How are we to represent a solid body, having width, breadth and thickness, on a piece of paper where the diagrams can have only breadth and width ?

This problem is solved by means of projections. Since the size of a solid body will be determined by the lengths and positions of its edges, we will first consider the diagrams necessary to fix the measurements of a straight line in space. Refer again to Fig. 54, *ab* is the projection of AB on a horizontal plane and this projection gives valuable information about the position in space of the line AB.

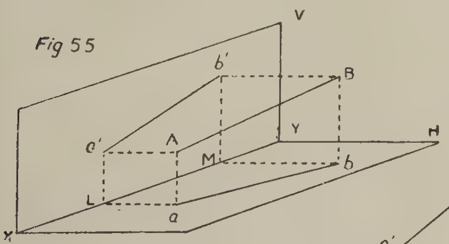
The projection of a line (or lines) on to a *horizontal* plane is called the *plan* ; but this, in itself, is insufficient exactly to determine AB for many lines can exist in space, all having the same plan *ab*. To fix AB exactly we need its projection on to another plane, and generally the vertical plane is the most convenient. The projection on to a vertical plane is called an *elevation*. Consider Fig. 55, AB is a line in space and *ab* is its projection on a horizontal plane (H), *a′b′* its projection on to a vertical plane (V). *ab* is the plan and *a′b′* the elevation.

Once the plan and elevation are given, the line is fixed ; and this fact gives a convenient method for practical work. XY, the line of intersection of the horizontal and vertical planes, is called the *ground line*. We take a sheet of paper and draw a horizontal line XY to denote the ground line. Above this line represents the vertical plane ; below it, the horizontal plane, so that we have simply rotated the horizontal plane about XY and thus have the plan and elevation on the same sheet of paper. By comparing Figs. 55 and 56 the following facts are obvious : *a′*L, *b′*M are the heights of A and B respectively above the horizontal plane, and L*a*, M*b* are the distances of A, B respectively from the vertical plane.

To find the true length of a line given its plan and elevation. By referring to Fig. 55 it will be seen that the true length of AB is the hypotenuse of a right-angled triangle whose base is equal to the length of the plan and whose perpendicular height is the difference in heights of A and B above the horizontal plane. Consider Fig. 57, *a′b′* is the elevation of a line in space and *ab* its plan. *b′*N is the difference in heights of A and B (Fig. 55), found from the elevation. Through the end *b* of the plan is shown a line at right angles to *ab*, its length being made equal to *b′*N. This gives the point C. *a*C is the true length of the line in space. ∠*Cab* is the angle that the line in space makes with its own plan.

Definitions. At this stage we need a few more definitions to help us to formulate the subject exactly. The *angle between a line and a plane* is defined as the angle between the line and its own projection on the plane. The *angle between two planes* is defined as the angle between two lines, one in each plane, which are drawn at right angles to the line of intersection of the planes through a

Fig 55



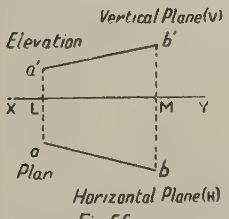


Fig 56

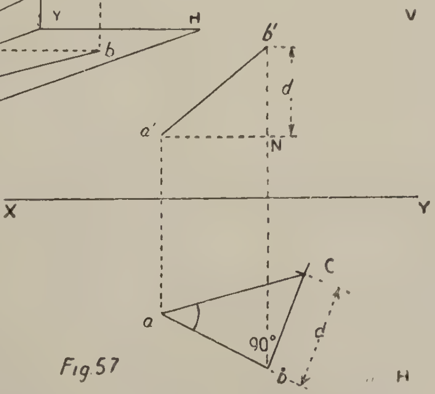


Fig 57

PLAN AND ELEVATION. *Fig. 55. Projecting a line in space on horizontal and vertical planes. Fig. 56. Plan and elevation. Fig. 57. Length of a line, given plan and elevation.*

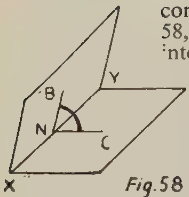


Fig. 58

common point, i.e. in Fig. 58, if XY is the line of intersection of the two planes, and N is any point in XY, then the angle BNC is the angle between the two planes where BN and CN are drawn perpendicularly to XY. A *cube* is a solid, all of whose faces are squares. A *pyramid* is a solid, all of whose faces except one meet in a point, called the *vertex*. A *triangular pyramid* (i.e. a pyramid with all its faces triangular in shape) is called a *tetrahedron*. A *regular tetrahedron* is one all of whose faces are equilateral triangles.

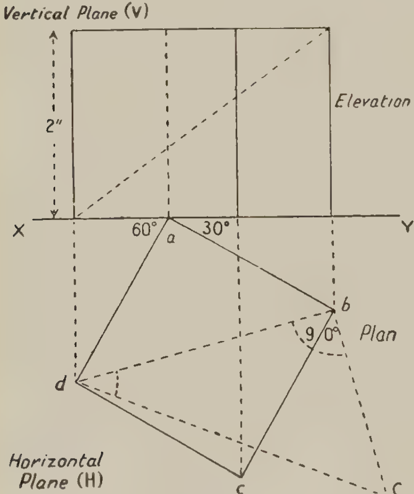


Fig 59

Fig. 59. Plan and elevation of a cube.

Problem. Draw the plan and elevation of a cube of edge 2 in., resting on the horizontal plane and whose vertical faces are inclined at 30° and 60° to the vertical plane. Find the length of a diagonal and the angle between the diagonal and the horizontal plane. Draw the ground line XY (Fig. 59), and below it a square *abcd* of side 2 in., one edge making 30° with XY. This square is the *plan* of the cube. From the four points *a*, *b*, *c*, *d*, project lines to the part above XY which represents the vertical plane. The height of the elevation must be 2 in. Notice which lines are dotted and which are thick; *bd* is the plan of a diagonal, so through *b* a perpendicular is drawn and *b*C is made equal to 2 in. (the height through which the diagonal rises in space). *d*C is the true

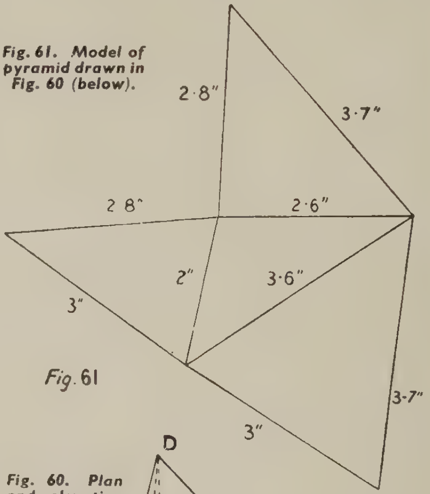


Fig. 61

Fig. 61. Model of pyramid drawn in Fig. 60 (below).

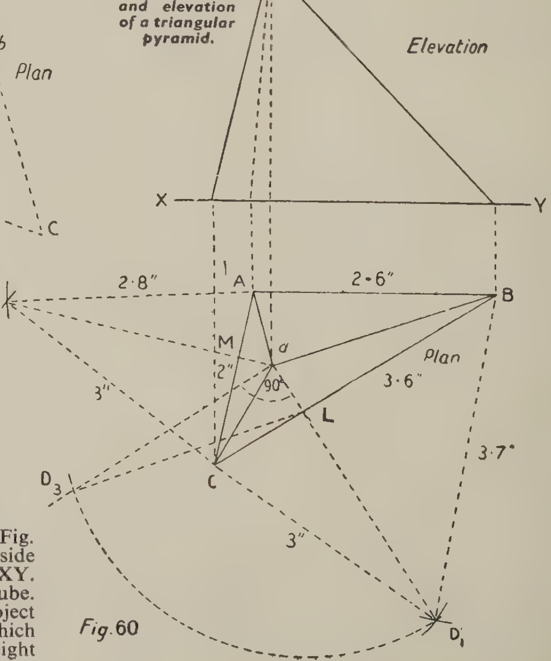


Fig. 60

Fig. 60. Plan and elevation of a triangular pyramid.

length of the diagonal and $\angle bdC$ the angle it makes with the horizontal plane. By calculation, using the theorem of Pythagoras, the diagonal is easily seen to be of length $\sqrt{12}$ in.

Problem. The six edges of a triangular pyramid ABCD are of lengths as follows :— AB = 2·6 in., BC = 3·6 in., CA = 2 in., AD = 2·8 in., BD = 3·7 in., CD = 3 in. Draw the plan of the pyramid when it is standing on the face ABC, and determine the height of D. Draw also the elevation of the pyramid on a vertical plane parallel to the edge AB.

The triangle ABC is first drawn, Fig. 60, then the point D_1 is found, making $BD_1 =$ 3·7 in., CD_1 = 3 in. Then BCD_1 is the actual shape of the face BCD which has, in effect, been rotated about the edge BC until it is brought in to the horizontal plane. Draw a perpendicular from D_1 on to BC, cutting it in L and produce. Similarly draw ACD_2 which is the true shape of the face ACD. Draw a perpendicular from D_2 on to AC and continue to cut D_1L produced in *d*. *d* is the plan of the vertex. Join A*d*, B*d*, C*d* which are the plans of the edges AD, BD, CD respectively. Now L*d* is the plan of a line from L to the vertex D and this line is equal in length to LD_1, so that we can very easily find the height of the pyramid. Draw a line through *d* perpendicular to D_1L produced. Cut this perpendicular (at D_3) by an arc of a circle, centre L and radius LD_1; then dD_3 is the height of the pyramid. A line XY is drawn parallel to AB and the elevation is constructed, the height being now known (dD_3). The reader should cut out a model as indicated in Fig. 61, which will then close up to be the required pyramid, and by drawing lines on this model he will be able to convince himself of the correctness of the above constructions.

For further work in simple practical geometry the reader should refer to Drawing, Vol. IV, pages 47–62.

EXERCISES

(1) Draw an angle of 66° and bisect it geometrically. Verify with a protractor.

(2) Draw two lines AB, BC each 3 in. long so that angle ABC = 120°. Find, geometrically, the centre of the circle passing through A, B and C and measure its radius.

(3) Draw a triangle having sides 6 in., 8 in. and 10 in. Find a geometrical method for drawing a circle inside the triangle to touch all three sides and measure its radius (*see* Theorems of Triangles, p. 195).

(4) Draw a circumscribed circle of the triangle given in Question (3), and measure radius.

(5) Draw the plan and elevation of a rectangular block of edges 2 in., 3 in. and 4 in., resting on a 3 in. × 4 in. face such that the 3 in. edge makes an angle of 45° with ground line. Find, geometrically, length of a diagonal and check by calculation.

(6) A regular tetrahedron has all its edges of length 3 in. Draw its plan when resting on any face, find the height of the vertex and draw an elevation on a plane parallel to one of the edges of its base. Verify the height of the vertex by calculation, using the theorem on medians in Lesson 5.

Answers to Exercises in Lesson 6

(1) 4π, 8, 1·1416 sq. in.
(2) 2·1 radians.
(3) arc = 3·49 in., area = 6·98 sq. in.

LESSON EIGHT

First Steps in Trigonometry

ARISING directly out of the geometrical work of Lesson 4 on similar triangles, we may adopt a new technique to examine the relations between the lengths of the sides of a triangle and the magnitude of its angles. Consider the diagram (Fig. 62) ; it consists of a number of similar right-angled triangles AB_1C_1, AB_2C_2, . . . AB_nC_n, all having the same angle at A. From the geometry of similar triangles it follows that the ratio of any pair of corresponding sides is equal, i.e.

$$\frac{B_1C_1}{AB_1} = \frac{B_2C_2}{AB_2} = \frac{B_3C_3}{AB_3} = \ldots = \frac{B_nC_n}{AB_n}$$

This ratio is constant therefore for the particular angle A. The ratio, the perpendicular divided by the hypotenuse, is useful to link up the sides of the triangle with the angle A because it will be constant for any particular angle at A and will not depend on the size of the triangle. This ratio is named the *sine* of the angle at A. Similarly from the same similar triangles :

$$\frac{AC_1}{AB_1} = \frac{AC_2}{AB_2} = \frac{AC_3}{AB_3} = \ldots = \frac{AC_n}{AB_n},$$

a constant for the angle A, and this ratio is defined as the *cosine* of the angle at A. Lastly,

$$\frac{B_1C_1}{AC_1} = \frac{B_2C_2}{AC_2} = \frac{B_3C_3}{AC_3} = \ldots = \frac{B_nC_n}{AC_n}$$

and this constant ratio is termed the *tangent* of the angle at A. These three ratios—the sine, cosine and tangent—are fundamental in the study of the relation between the sides and angles of any triangle and it is this study which forms the subject of *Trigonometry*. The ratios are invariably abbreviated to sin (pronounced sine), cos (pronounced cŏss) and tan.

To summarize, then, in any right-angled triangle ABC (Fig. 63), if the angle at A be considered as being of magnitude A degrees, then the definitions we have stated are:

$$\text{(i) } \sin A = \frac{BC}{AB} \left\{ \text{i.e. } \frac{\text{the side opposite to A}}{\text{hypotenuse}} \right\}$$

$$\text{(ii) } \cos A = \frac{AC}{AB} \left\{ \text{i.e. } \frac{\text{the side adjacent to A}}{\text{hypotenuse}} \right\}$$

$$\text{(iii) } \tan A = \frac{BC}{AC} \left\{ \text{i.e. } \frac{\text{side opposite to A}}{\text{side adjacent to A}} \right\}$$

Before continuing with the study of Trigonometry it is important for the student to become thoroughly familiar with the above definitions. This can best be achieved by actual practical work for which the student will require a protractor (a scale for measuring angles), a ruler for measuring lengths (preferably in inches and fiftieths) and two set squares, one giving angles of 30° and 60° and the other 45°.

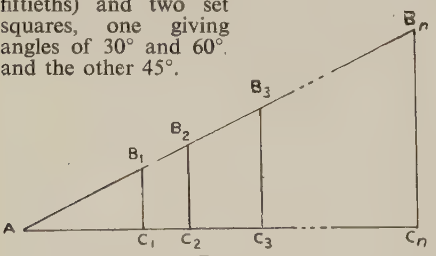


Fig. 62

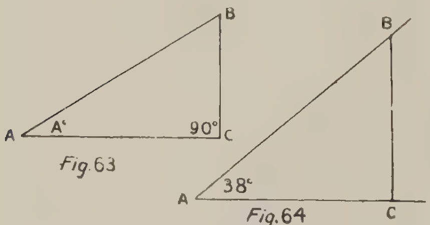
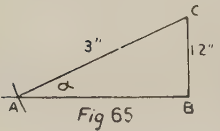


Fig. 63

Fig. 64



Figs. 62-65. Trigonometrical relations of sides and angles in right-angled triangles (see text).

Example 1. Find the sine, cosine and tangent of 38° (Fig. 64). Draw a horizontal line and from one end (A), set up an angle of 38° with the protractor. The line at this angle will be the hypotenuse so that it will be convenient to make it some length which will be an easy divisor, say 2 in. Mark off the point B, such that AB = 2 in., and then by means of either of the set squares or the protractor draw a perpendicular from B on to the horizontal through A, meeting it in C. Measure BC and AC. Working through this problem the lengths of BC and AC were respectively 1·24 in. and 1·58 in. The hypotenuse was made equal to 2 in. so that

$$\sin 38 = \frac{1{\cdot}24}{2} = 0{\cdot}62$$

$$\cos 38 = \frac{1{\cdot}58}{2} = 0{\cdot}79$$

$$\tan 38 = \frac{1{\cdot}24}{1{\cdot}58} = \frac{0{\cdot}62}{0{\cdot}79} = 0{\cdot}78$$

It should be noticed that $\tan 38° = \frac{\sin 38°}{\cos 38°}$ and the question naturally arises whether the tangent of any angle is always the sine of the angle divided by the cosine. This will be considered later.

Example 2. Find the angle whose sine is 0·4 (Fig. 65).

Let the angle whose sine is 0·4 be α, then $\sin \alpha = 0{\cdot}4 = \frac{0{\cdot}4}{1}$; so that we require a right-angled triangle with one side equal to 0·4 and the hypotenuse equal to 1. This would give a small and inaccurate diagram so we multiply numerator and denominator by some convenient number to give a larger diagram, e.g. $\sin \alpha = \frac{0{\cdot}4}{1} = \frac{1{\cdot}2}{3}$ (multiplying by 3), then we require a right-angled triangle, one side 1·2 in. and hypotenuse 3 in.

Draw a horizontal line about 4 in. long and from one end (B) set up a perpendicular of length 1·2 in., giving the point C on the diagram, and with this point as centre strike an arc of radius 3 in. to cut the horizontal through B in A. α is then the angle CAB which, measured by a protractor, is 23·2° or 23° 12′.

NOTE. The angle whose sine is 0·4 is written $\sin^{-1}(0{\cdot}4)$. Thus $23° 12' = \sin^{-1}(0{\cdot}4)$ and $\sin(23° 12') = 0{\cdot}4$ mean the same.

In these last two examples there is, of course, a margin of practical error. The actual values of the sines, cosines and tangents of all angles between 0° and 90° have been calculated and set out in tabular form. The student will need such a set of tables and is advised to work through the last two examples himself, comparing his results both with those obtained above and with the values found from the tables, which are as follows:—

Ex. (1) $\sin 38° = 0{\cdot}6157$, $\cos 38° = 0{\cdot}7880$, $\tan 38° = 0{\cdot}7813$;

Ex. (2) $\sin^{-1}(0{\cdot}4) = 23° 35'$.

Relation between Sine, Cosine and Tangent. In Example 1, page 206, we found that

$\tan 38° = \dfrac{\sin 38°}{\cos 38°}$ and this was only a particular case of a general relation that

$$\tan A = \frac{\sin A}{\cos A}$$

This may be easily seen from the definitions of sin A and cos A. In the diagram of Fig. 63

$\sin A = \dfrac{BC}{AB}$ and $\cos A = \dfrac{AC}{AB}$ by definition.

Therefore

$$\frac{\sin A}{\cos A} = \frac{\;\frac{BC}{AB}\;}{\;\frac{AC}{AB}\;} = \frac{BC}{AB} \cdot \frac{AB}{AC} = \frac{BC}{AC} = \tan A.$$

Another fundamentally important relation between sin A and cos A comes directly from Pythagoras' Theorem. This theorem applied to the triangle above, gives (Fig. 63):

$$(BC)^2 + (AC)^2 = (AB)^2$$

or dividing both sides by $(AB)^2$

$$\left\{\frac{BC}{AB}\right\}^2 + \left\{\frac{AC}{AB}\right\}^2 = 1$$

But $\dfrac{BC}{AB}$ has been defined as sin A, so that

$$\left\{\frac{BC}{AB}\right\}^2 = (\sin A)^2 \text{ or } \sin^2 A$$

(as it is written in trigonometrical work).

Similarly $\left\{\dfrac{AC}{AB}\right\}^2 = (\cos A)^2$ which is written $\cos^2 A$, so that the relation above becomes

$$\sin^2 A + \cos^2 A = 1.$$

It may be noticed here that the two fundamental relations above have been proved for any values of A between 0° and 90°. Later it will be seen that when meanings have been given to sin A, cos A and tan A for values of A greater than 90° these relations are still true.

Since both the sine and cosine of A are one or other of the sides adjacent to the right angle divided by the hypotenuse, it follows that both sin A and cos A must be less than 1. Tan A, on the other hand, may have any value less than 1 or greater than 1 according as BC is less than AC or greater than AC. In mathematical work 'less than' is denoted by the symbol < and 'greater than' by >. Thus our condition above may be expressed mathematically by

$$\tan A < 1 \text{ if } BC < AC$$

and

$$\tan A > 1 \text{ if } BC > AC.$$

Example. Given $\cos A = 5/13$, to find tan A without using tables.

From the identity

$$\sin^2 A + \cos^2 A = 1$$

we obtain, since $\cos A = 5/13$,

$$\sin^2 A + (5/13)^2 = 1$$

i.e.

$$\sin^2 A = 1 - \frac{25}{169} = \frac{144}{169}$$

so that

$$\sin A = \sqrt{\frac{144}{169}} = \frac{12}{13}$$

Finally

$$\tan A = \frac{\sin A}{\cos A} = \frac{12/13}{5/13} = \frac{12}{5} = 2{\cdot}4.$$

Cosec A, sec A and cot A. Arising out of the three fundamental trigonometrical ratios sin A, cos A and tan A it has been found convenient to give special names to the reciprocals of these ratios.

Thus *cosecant* A is defined as 1 divided by sin A, *secant* A is defined as 1/cos A and *cotangent* A is 1/tan A. Cosecant A is shortened to cosec A, secant A to sec A and cotangent A to cot A. Thus we have altogether six trigonometrical ratios and there are, of course, a number of relations connecting them.

Firstly since

$$\tan A = \frac{\sin A}{\cos A} \text{ and } \cot A = \frac{1}{\tan A};$$

it follows that

$$\cot A = \frac{\cos A}{\sin A}.$$

Again, since

$$\tan A = \frac{\sin A}{\cos A}$$

$$\tan^2 A = \frac{\sin^2 A}{\cos^2 A}$$

$$\begin{aligned} 1 + \tan^2 A &= 1 + \frac{\sin^2 A}{\cos^2 A} \\ &= \frac{\cos^2 A + \sin^2 A}{\cos^2 A} \\ &= \frac{1}{\cos^2 A} \text{ because } \sin^2 A + \cos^2 A = 1 \\ &= \sec^2 A \text{ because } \sec A = \frac{1}{\cos A}. \end{aligned}$$

Lastly,

$$1 + \cot^2 A = 1 + \frac{\cos^2 A}{\sin^2 A}$$

$$= \frac{\sin^2 A + \cos^2 A}{\sin^2 A}$$

$$= \frac{1}{\sin^2 A}$$

$$= \text{cosec}^2 A.$$

Since sin A and cos A were both less than 1, it follows necessarily that cosec A and sec A are greater than 1.

To sum up, then, we have had the following relations:

$$\tan A = \frac{\sin A}{\cos A}, \ \cot A = \frac{1}{\tan A} = \frac{\cos A}{\sin A},$$

$$\text{cosec}\, A = \frac{1}{\sin A}, \ \sec A = \frac{1}{\cos A},$$

$$\sin^2 A + \cos^2 A = 1, \ 1 + \tan^2 A = \sec^2 A,$$

$$1 + \cot^2 A = \text{cosec}^2 A.$$

These relations are called *identities*, one side being the same as the other side but expressed in a different form. This is quite a different type of relation from an equation; something which is true for only a limited number of values of A. Identities are true for all values of A, they merely express an identical relation in different forms. It is very important for more advanced work to be able to manipulate identities from one form to another and we shall consider the technique of this manipulation at a later stage.

EXERCISES

(1) Draw an angle of 22°. Find its sine, cosine and tangent.

(2) Repeat this question, but make the diagram about twice as large. Confirm that the values obtained are more accurate than those above by comparing with the values given in tables.

(3) Construct the angle whose cosine is 0·52. Measure it and find its sine and tangent graphically.

(4) A vertical post in the ground of height 2 ft. throws a shadow of length 4½ ft. How high is a flag-pole if its shadow measures 67½ ft.?

(5) ABC is a triangle right-angled at B. Find the lengths of the other two sides in terms of (i) AB and the angle A, (ii) AB and the angle C, (iii) AC and the angle A.

(6) If sin A = ½, find the value of $1 + \tan^2 A$.

(7) Given that sin A = 4/5 find the value of $(\sin A + \cos A)^2$ and $\sin^2 A + \cos^2 A$.

(8) Prove geometrically that the tangents of all angles between 45° and 90° are greater than 1.

Answers to Exercises in Lesson 7

(2) 3 in., (3) 1 in., (4) 5 in., (5) 5·385 in., (6) 2·45 in.

LESSON NINE

Trigonometry of the Right-angled Triangle

We now proceed to the consideration of trigonometrical relations and ratios of the right-angled triangle, considering first a few cases of common occurrence.

Trigonometrical Ratios of 30°, 45°, 60°. These three angles are of common occurrence and their trigonometrical ratios can be established very easily. Consider a square ABCD of side 1 in., divided in two by the diagonal AC (Fig. 66). Then the angles of the triangle ABC are 45°, 45° and 90°. From Pythagoras' Theorem the length of the diagonal AC is $\sqrt{(1^2+1^2)} = \sqrt{2}$ in. Whatever the side of the original square had been, the ratio of the three sides of the triangle would always have been $1 : 1 : \sqrt{2}$, since they are similar triangles. Thus by choosing 1 unit of length for the side of the square we are enabled at once to write down the trigonometrical ratios.

$\sin 45° = BC/AC = 1/\sqrt{2}$,
also $\cos 45° = AB/AC = 1/\sqrt{2}$,
and $\tan 45° = BC/AB = 1$;
thus cosec 45° and sec 45° are both $\sqrt{2}$
and cot 45° is 1.

The ratios for the angles 30° and 60° are obtained by dividing an equilateral triangle in two by drawing a perpendicular from any vertex on to the opposite side as shown in the diagram (Fig. 67). For convenience take the side of the original equilateral triangle as 2 units, so that AB = 2 units, BD = 1 unit (since the perpendicular AD bisects the side BC) and consequently, from Pythagoras' Theorem $AD = \sqrt{(AB)^2 - (BD)^2} = \sqrt{(4-1)} = \sqrt{3}$. Again, whatever length of side we had chosen for the original equilateral triangle

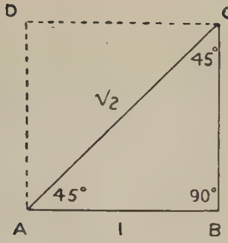


Fig. 66

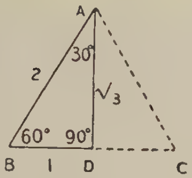


Fig 67

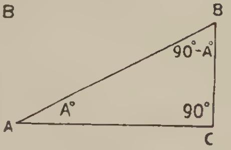


Fig 68

Figs. 66-68. Trigonometrical ratios of various angles.

the sides AB, BD, AD would have been in the ratio $2 : 1 : \sqrt{3}$.

Thus $\sin 60° = AD/AB = \sqrt{3}/2$,
$\cos 60° = BD/AB = 1/2$,
and $\tan 60° = AD/BD = \sqrt{3}$.

From the same triangle we may obtain the trigonometrical ratios of 30°,

for $\sin 30° = BD/AB = 1/2$,
$\cos 30° = AD/AB = \sqrt{3}/2$,
and $\tan 30° = BD/AD = 1/\sqrt{3}$.

From these, by inverting the values, we find the cosec, sec and cot of 30° and 60°.

It will be a great help to the student if he can memorize some of the above values, and for simplicity we may draw up a table of the most important values as follows:

	30°	45°	60°
sin	$\frac{1}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{\sqrt{3}}{2}$
cos	$\frac{\sqrt{3}}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{2}$
tan	$\frac{1}{\sqrt{3}}$	1	$\sqrt{3}$

Relations between Trigonometrical Ratios of A° and 90°−A°. It will be noticed in the above table that sin 30° = cos 60° and cos 30° = sin 60°, which suggests that there may be a relation between the ratios of any angle A° and its *complement*, that is, 90° − A°. We will look into this question further Consider any right-angled triangle ABC (Fig. 68); then, by definition $\sin A = \frac{BC}{AB}$. But $\frac{BC}{AB}$ is also the cosine of the angle at B which is 90° − A°, so that

sin A = cosine of 90° − A°, which is written cos (90° − A°).

Similarly

$\cos A = \frac{AC}{AB}$ and $\frac{AC}{AB}$ is also sin B, i.e. sin (90° − A°)

so that we have

$\cos A = \sin (90° - A°)$.

Lastly,

$$\tan A = \frac{BC}{AC} = \cot B = \cot (90° - A°), \text{ and}$$

$$\cot A = \frac{AC}{BC} = \tan B = \tan (90° - A°).$$

Finally, then, we have the following important results:

$$\sin A = \cos (90° - A),$$
$$\cos A = \sin (90° - A),$$
$$\tan A = \cot (90° - A),$$
$$\cot A = \tan (90° - A).$$

Example. Without using tables, show that

$$\cos 40°.\ \cos^2 50°.\ \cot 50° = \sin^3 40°.$$

Bearing in mind the above relations, and noticing that 40° + 50° = 90°, we have cos 50° = sin 40° and cot 50° = tan 40°, so that the left hand side becomes:

$$\cos 40° \sin^2 40° \frac{\sin 40°}{\cos 40°} = \sin^3 40°.$$

Simple Problems in Trigonometry. We can now use the trigonometry we have learned in solving simple problems. Suppose, for example, we are given the problem of finding the height of a flag-pole (Fig. 69). What measurements must be made on the ground in order that we may calculate the height? If we walk a distance away from the foot of the pole and notice the angle that the top of the pole makes with the horizontal (called the *angle of elevation* of the top of the pole) then we have sufficient information for our purpose. As an example, let FP represent the flag-pole and suppose that a point 25 yds. away from the foot of the pole, the angle of elevation of P is 30° (Fig. 69). Then from trigonometry—

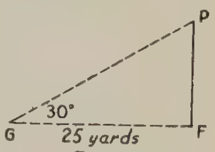


Fig. 69

$$\frac{FP}{25} = \tan 30° = \frac{1}{\sqrt{3}}$$

so that

$$FP = \frac{25}{\sqrt{3}} \text{ yds.}$$
$$= 43{\cdot}3 \text{ ft.}$$

It is important to notice the valuable implications of the last example; that inaccessible distances may be calculated and inaccessible points located by measuring suitable distances and angles.

Let us consider some other cases and, for the present, we shall restrict ourselves to types where all the measurements of lines and angles are in the same vertical plane.

(1) To find the height and position of an object where the foot of the perpendicular from the object on to the ground is inaccessible.

Let LM (Fig. 70) represent the height to be found and suppose that we can find the angles of elevation of L at two points (A and B) in the horizontal line through M. Then from the definition of the tangent of an angle, $\frac{LM}{AM} = \tan A$ and $\frac{LM}{BM} = \tan B$ or alternatively—

$$AM = LM/\tan A = LM \times \cot A \text{ and}$$
$$BM = LM/\tan B = LM \times \cot B.$$

Finally
$$\begin{aligned} AB &= AM - BM \\ &= LM \times \cot A - LM \times \cot B \\ &= LM(\cot A - \cot B) \end{aligned}$$

so that
$$LM = \frac{AB}{\cot A - \cot B}$$

This formula gives the height LM in terms of the distance AB and the two angles of elevation. Knowing LM, the position of M is fixed, since $BM = LM \times \cot B$.

(2) To find the height and position of an object knowing the angles of elevation from two points, a known distance apart, one on each side of the object.

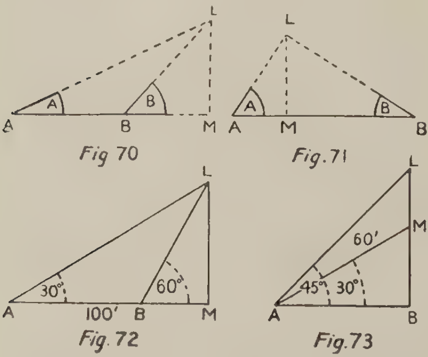


Fig 70 *Fig.71* *Fig. 72* *Fig.73*

PROBLEMS. Finding height from angles of elevation (Figs. 70–73); general and particular cases.

As before let LM denote the height to be found, and AB the known distance (Fig. 71). The three points A, M, B are all in a straight line since we are only considering cases where all the measurements are in the same plane. Reasoning as in the last case,

$$LM = AM \times \tan A$$

and also $LM = BM \times \tan B$

i.e. $AM = LM \times \cot A$

and $BM = LM \times \cot B$

so that
$$\begin{aligned} AB &= AM + BM \\ &= LM \times \cot A + LM \times \cot B \\ &= LM(\cot A + \cot B) \end{aligned}$$

i.e.
$$LM = \frac{AB}{\cot A + \cot B}$$

giving LM in terms of AB and the angles A and B. M is fixed since $AM = LM \times \cot A$.

The following examples illustrate the above, and similar types.

Example 1. From two points, 100 ft. apart on level ground, the angles of elevation of the top of a tower are 30° and 60°. Find the height of the tower and the distance of the foot from the nearest point.

Consider the diagram (Fig. 72):

$$LM = BM \times \tan 60° = BM \times \sqrt{3},$$

also
$$LM = AM \times \tan 30° = AM \times \frac{1}{\sqrt{3}}$$

so that
$$AM = LM \times \sqrt{3},$$
$$\text{and } BM = LM \times \frac{1}{\sqrt{3}}.$$
$$\text{Thus } AB = LM\left\{\sqrt{3} - \frac{1}{\sqrt{3}}\right\}$$
$$\text{and } LM = \frac{AB}{\sqrt{3} - \frac{1}{\sqrt{3}}} = \frac{100}{\sqrt{3} - \frac{1}{\sqrt{3}}}$$
$$= 86{\cdot}6 \text{ ft.}$$

Therefore
$$BM = LM \times \frac{1}{\sqrt{3}} = 50 \text{ ft.}$$

Example 2. A flag-pole is placed vertically on a hill which has an even slope of 30°. From a point 60 ft. down the hill, the angle of elevation of the top of the pole is 45°. Find the height of the pole.

In the diagram (Fig. 73) LM represents the flag-pole, A the point from which the elevation is 45° so that AM = 60 ft. AB is horizontal so that $\angle MAB = 30°$. $AB = 60 \times \cos 30° = 60 \times \frac{\sqrt{3}}{2} = 30\sqrt{3}$ ft., and since $\angle LAB = 45°$, AB = LB. Also $MB = 60 \times \sin 30° = 30$ ft.

Finally
$$\begin{aligned} LM &= LB - MB \\ &= AB - MB \\ &= 30\sqrt{3} - 30 \text{ ft.} \\ &= 21{\cdot}96 \text{ ft.} \end{aligned}$$

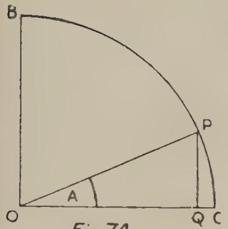


Fig. 74

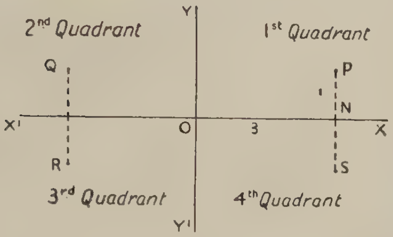


Fig. 75

Fig. 74. Trigonometrical ratios of angles of 0 and 90 degrees. Fig. 75. Coordinate references. Fig. 76. Ratios of angles of any size.

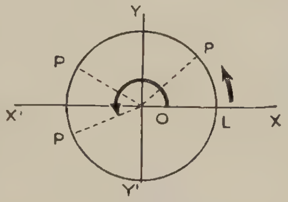


Fig. 76

Angles of 0° and 90°. We will now find the trigonometrical ratios of 0° and 90°. Draw a quadrant of a circle BOC (Fig. 74) and let P be any point on the circumference. Draw a perpendicular PQ. Then if ∠POQ = A, sin A = $\frac{PQ}{OP}$. If P approaches C, then the angle A becomes smaller and smaller and consequently PQ becomes shorter. OP remains constant in length. As P becomes coincident with C, the angle A becomes zero and PQ also becomes zero so that sin 0° = $\frac{0}{OP}$ = 0. Similarly cos A = $\frac{OQ}{OP}$ and as P approaches C, OQ becomes equal to OC. Thus cos 0° = $\frac{OC}{OC}$ = 1 and therefore tan 0° = $\frac{\sin 0^\circ}{\cos 0^\circ}$ = 0. By making P approach B we obtain sin 90° = $\frac{OB}{OB}$ = 1 and cos 90° = 0. Thus tan 90° = $\frac{1}{0}$ = an infinitely large quantity.

Coordinates. In the trigonometry which we have studied so far, we have defined the ratios sine, cosine and tangent only for angles between 0° and 90°. It is very important to extend these definitions to include all angles whatever their size, and in order to do this we must, first of all, consider the use of what are termed *coordinates*. Consider two lines XOX′ and YOY′ drawn at right angles (Fig. 75). With these as reference lines we can fix the position of any point by giving it two numbers. For instance the point P is reached from O by moving a certain distance (for example, say 3 units) along OX to N and then moving at right angles (parallel to OY) for a certain distance (say 1 unit). These distances, 3 units and 1 unit, are called the *x coordinate* and *y coordinate* respectively of the point P. They do in fact fix the position of P with respect to the reference lines OX and OY. The *x* coordinate is always written first so that P is designated as the point (3, 1).

If we consider the movement from O towards X as a positive direction we must consider a movement from O to X′ as a negative direction. Thus the coordinates of the point Q, for instance, would be (−3, 1) indicating that to reach Q from O we must proceed in the X′ direction (i.e. the negative X direction) for 3 units and then in the positive Y direction for 1 unit. Correspondingly, points within the quadrant X′OY′ have both the *x* and *y* coordinates negative while points within XOY′ have the *x* coordinate positive but the *y* coordinate negative. Thus R is the point (−3, −1) and S the point (3, −1). The four quadrants are referred to as the first quadrant, second quadrant and so on, as indicated.

Trigonometrical Ratios of Angles of Any Size. If we draw two reference lines (or *axes*, as they are termed) XOX′ and YOY′ (Fig. 76) and choose any point L on the positive X axis, then we can imagine the line OL rotating about O in an anti-clockwise direction. If P be any point on the circumference in the first quadrant then ∠POL is less than 90°. If now OP is rotated until P lies somewhere in the second quadrant then the ∠POL will be between 90° and 180°. Similarly if P be in the third quadrant the angle POL (always measured in the anti-clockwise direction) will have a size between 180° and 270° and finally if P lies in the fourth quadrant, ∠POL lies between 270° and 360°. This provides us with a method of defining the sine, cosine and tangent of any angle whatever its size, which is as follows:

$$\sin \angle POL = \frac{y \text{ coordinate of P}}{OP}$$

$$\cos \angle POL = \frac{x \text{ coordinate of P}}{OP}$$

$$\text{and } \tan \angle POL = \frac{y \text{ coordinate of P}}{x \text{ coordinate of P}}$$

Since in all the quadrants, except the first, one of the coordinates at least is negative, these extended definitions must mean that for angles greater than 90° one of the trigonometrical ratios at least is negative, OP always being taken as positive. We will consider this more fully by means of actual examples.

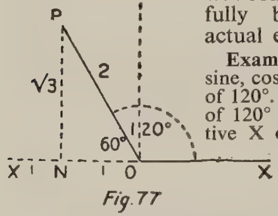


Fig. 77. Sine, cosine and tangent of angle of 120 deg.

Example. Find the sine, cosine and tangent of 120°. Draw an angle of 120° taking the positive X direction as the initial line. Then $\angle X'OP = 60°$ so that if ON is numerically 1 unit in length, $PN = \sqrt{3}$ units and $OP = 2$ units (Fig. 77). Then the coordinates of P are $(-1, \sqrt{3})$ and from our definitions

$$\sin 120° = \frac{y \text{ coordinate of P}}{OP} = \frac{\sqrt{3}}{2},$$

$$\cos 120° = \frac{x \text{ coordinate of P}}{OP} = \frac{-1}{2} \text{ and}$$

$$\tan 120 = \frac{\sqrt{3}}{-1} = -\sqrt{3}.$$

For every position of P in the second quadrant, the x coordinate is negative and the y coordinate positive, so that for all angles between 90° and 180° the sine is positive, the cosine is negative and therefore the tangent is negative. For any point P in the third quadrant, the x coordinate is negative, the y coordinate is also negative, so that angles in the third quadrant have their sine and cosine negative, but their tangent positive. By similar reasoning, for the fourth quadrant we find that the sine and tangent are negative but the cosine is positive. The above information is summarized in Fig. 78.

SIN + COS − TAN −	SIN + COS + TAN +
SIN − COS − TAN +	SIN − COS + TAN −

Fig. 78

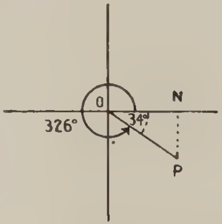


Fig. 78. When sin, cos and tan are positive or negative. Fig. 79. Finding sin, cos and tan of angle exceeding three right angles.

Example. Find by drawing and measurement the sine, cosine and tangent of 326°. This angle falls in the fourth quadrant. Draw OP in position (Fig. 79) making it some convenient length, say 3 in. Draw a perpendicular PN. Measure ON and PN in inches.

Then $\sin 326° = \frac{-PN}{3}$ $\cos 326° = \frac{+ON}{3}$ and $\tan 326° = \frac{-PN}{ON}$ Notice that the *numerical* values (that is, apart from the sign) of sin, cos and tan 326° will be the same as for 360°−326°, i.e. 34°.

EXERCISES

(1) A man stands on the straight bank of a river directly opposite to a tree on the other side. He walks along the bank for 25 yds. and finds that the tree makes an angle of 45° with the direction in which he has just moved. How wide is the river ?

(2) From a certain point the elevation of a barrage balloon is 60°. A person walks for 100 yds. in a straight line passing directly under the balloon. The angle of elevation is then 30°. What is the height of the balloon and how far did the person walk before he was directly under it ?

(3) From a rowing boat the angle of elevation of the top of the cliffs is 5° 6′ and after rowing towards the shore for some time the angle is 7° 48′. If the cliffs are known to be 100 ft. high, how far was the boat rowed between making the two observations and how far remains before land will be reached?

(4) Find by drawing and measurement the sine, cosine and tangent of 156°, 200°, 236°, 315°.

(5) Deduce the sine, cosine and tangent of 180°, 270°, 360°.

(6) Prove that the fundamental identities of Lesson 8 are true for angles of any size.

(7) Find by drawing the angle in the third quadrant whose tangent is 3·5.

Answers to Exercises in Lesson 8

(1) and (2) From tables sin 22° = 0·3746, cos 22° = 0·9272, tan 22° = 0·4040.

(3) 58° 40′. From tables sin 58° 40′ = 0·8542. tan 58° 40′ = 1·6426.

(4) 30 ft.

(5) (i) AC = AB sec A, BC = AB tan A.
(ii) AC = AB cosec C, BC = AB cot C
(iii) AB = AC cos A, BC = AC sin A

(6) 4/3. (7) 49/25, 1.

LESSON TEN

Elementary Ideas in Algebra

When we say that a group consists of three objects and use the symbol 3 to represent its *number* or its *size*, we use the same symbol 3 for any other group of the same size. The members of the group may differ from each other in a variety of respects, e.g. it may consist of a cup, a saucer and a plate. The symbol 3 represents something about the group which is the same as that in a group consisting of a knife, a fork and a spoon.

When we say that $3 + 2 = 5$ we are describing the way in which groups combine as regards their size, and in doing so we ignore all other aspects of the situation. It is for this reason that arithmetic is of such universal value; it applies to widely diverse circumstances because all it demands is that *size* alone shall be the feature with which we are concerned. Were this not so a different kind of arithmetic would be required for each special occasion.

We can carry arithmetic a stage farther along these lines. We have seen that an even number always has a factor 2 so that it can be written $2 \times n$ where n is any number whatsoever, even or odd. Thus, if we wish to discuss *even numbers in general* and not a particular even number like 2 or 4 or 6, we use the number $2 \times n$. In the same way, if we wish to discuss odd numbers in general and not a particular odd number, we use the number $2 \times n + 1$. We shall see in a moment how such numbers are used, but it is important to realize at this stage that $2 \times n$ or $2 \times n + 1$ have as good a claim to be considered as numbers as 16, or 158. It is more general, that is all, and therefore enables us to discuss more general problems and to arrive at more general answers.

Remarks on Notation. When convenient we propose to drop the sign × for multiplication, provided no confusion arises. For instance, if we write $2n$ we mean $2 \times n$, or, what is of course the same thing, $n \times 2$. We do not usually write $n2$ although it is not false. It is simply a custom to write the *particular* symbol first and the general symbol second.

Thus, $8n$ or $3x$ or $7y$ or $25z$ mean respectively $8 \times n$, $3 \times x$, $7 \times y$, $25 \times z$ where n, x, y, z are numbers not yet specified. They may be any number, varying from one occasion to the next. For that reason they are called *variables*, whereas particular numbers like 8, 3, 7, 25 are called *constants*.

It is customary to represent a constant by letters at the beginning of the alphabet, a, b, c, etc., and variables by letters towards the end, viz. x, y, z.

Illustrations. Let us tabulate the values of $5x - 4$ for $x = 1, 2, 3, \ldots 9$.

$$\begin{aligned} x &= 1, & 5x - 4 &= 5 \times 1 - 4 = 1 \\ x &= 2, & 5x - 4 &= 5 \times 2 - 4 = 6 \\ x &= 3, & 5x - 4 &= 5 \times 3 - 4 = 11 \\ x &= 4, & 5x - 4 &= 5 \times 4 - 4 = 16. \end{aligned}$$

The reader can easily complete this calculation. Note that the numbers 1, 6, 11, 16, ... increase each time by 5. Why is this ?

Addition and Subtraction in Algebra. Everybody uses algebra, even those who imagine they do not know any. If you have to add 2 ft. 4 in. to 6 ft. 3 in., you would do it like this:

$$\begin{array}{l} 2 \text{ ft. } 4 \text{ in.} \\ 6 \text{ ft. } 3 \text{ in.} \\ \hline 8 \text{ ft. } 7 \text{ in.} \end{array}$$

But of course 2 ft. 4 in. is really 2 ft. plus 4 in., so that for economy in writing we might set it out like this:

$$\begin{array}{l} 2f + 4i \\ 6f + 3i \\ \hline 8f + 7i \end{array}$$

Here f stands for feet and i for inches.

This is algebra ! Now the interesting point to notice about this is its generality. For suppose a company were holding a board meeting of financiers and industrialists. Suppose they entered the board room in two groups, one of 2 financiers and 4 industrialists and the other of 6 financiers and 3 industrialists. We could add the two groups by exactly the same process as before, viz.:

$$\begin{array}{l} 2f + 4i \\ 6f + 3i \\ \hline 8f + 7i \end{array}$$

The same would hold if f stood for Frenchmen and i for Irishmen, and, indeed, if they stood for any two distinct types. For example, $f = 1$ group of 1 dozen eggs and i another group of 1 score eggs, the addition sum given above would read :

If we add 2 groups of 1 dozen eggs and 4 groups of 1 score eggs, to 6 groups of 1 dozen and 3 groups of a score, the result is obviously 8 groups of a dozen eggs and 7 groups of a score of eggs.

In this case we check it up as follows:

$$\begin{array}{l} 2f + 4i = 2 \times 12 + 4 \times 20 = 104 \text{ eggs} \\ 6f + 3i = 6 \times 12 + 3 \times 20 = 132 \text{ eggs} \\ \hline 8f + 7i = 8 \times 12 + 7 \times 20 = 236 \text{ eggs.} \end{array}$$

What we have done with two items can equally be done with any number. Thus:

$$\begin{array}{r} 3a + 4b + 5c + 6d \\ 4a + 5b + 6c + 3d \\ 7a + b + c + 2d \\ 11a + 3b + 2c + d \\ a + 9b + 70c + 12d \\ \hline 26a + 22b + 84c + 24d \end{array}$$

They need not all be positive signs, for after all it is not difficult to give a meaning to such an expression as $6f - 3i$ if f stands for dozens and i for scores.

Thus we could have addition sums like this:

$$\begin{array}{r} 3a - 4b + 8c \\ 5a + 7b - 6c \\ \hline 8a + 3b + 2c \end{array}$$

Subtraction follows the same way. Thus:

$$\begin{array}{ll} \text{from} & 7a + 8b \\ \text{take} & 3a + 5b \\ \cline{2-2} \text{answer} & 4a + 3b \end{array}$$

Each item is taken from its appropriate column. The result in any column may itself be negative. Thus:

$$\begin{array}{ll} \text{from} & 8a + 3b \\ \text{take} & 6a + 8b \\ \cline{2-2} \text{answer} & 2a - 5b \end{array}$$

This follows since $3 - 8 = -5$ or $3b - 8b = -5b$; and $8 - 6 = 2$, or $8a - 6a = 2a$.

These addition and subtraction sums might have been conducted without writing the items one under the other. For example, if we wish to add $7x + 5y + 4z$ to $3x - 4y + 11z$ we could write it like this:

$$\begin{array}{rl} & (7x + 5y + 4z) + (3x - 4y + 11z) \\ = & 7x + 5y + 4z + 3x - 4y + 11z \\ = & (7x + 3x) + (5y - 4y) + (4z + 11z) \\ = & 10x \quad + \quad y \quad + \quad 15z. \end{array}$$

On the other hand, if we wish to subtract them we write:

$$\begin{array}{rl} & (7x + 5y + 4z) - (3x - 4y + 11z) \\ = & 7x + 5y + 4z - 3x + 4y - 11z \\ & \qquad\qquad \text{(see explanation below)} \\ = & (7x - 3x) + (5y + 4y) + (4z - 11z) \\ = & 4x \quad + \quad 9y \quad - \quad 7z \end{array}$$

Note that when we removed the bracket in the second line where a − sign stood in front of that bracket, we altered the sign of each term that had previously fallen within the bracket. Why was this?

In the first place it is clear that to add − 6 to 10 is really to take 6 away. In symbols this means that $10 + (-6)$ is the same statement as $10 - (+6)$ and in both cases this becomes $10 - 6 = 4$. Thus the − sign becomes dominant.

Now consider what happens if we take − 6 *away* from a number, say 10. This would be equivalent to writing $10 - (-6)$. But to take − 6 *away* is really to *add* 6; thus this may also be written $10 + 6$; or $10 - (-6) = 10 + 6$.

A minus sign in front of a bracket changes a − sign inside to a +, and a + sign inside to a − sign. If we think of it in terms of direction:

$+1$ means take one step to the right
-1 means take one step in the reverse direction
$-(-1)$ means take one step in the reverse direction to that of -1, i.e. take one step to the right.

Thus $-(-1) = +1$.

Clearly this would be equally valid if we had $-5(-6) = 30$.

We are really dealing here with the multiplication of negative numbers.

Algebraically, therefore, we can write these rules as follows:

$$\begin{array}{l} (+a)(+b) = +ab \\ (-a)(+b) = -ab \\ (+a)(-b) = -ab \\ (-a)(-b) = +ab \end{array}$$

In this the two brackets standing alongside each other with no symbol between such as $(+a)(+b)$ imply that the contents of the brackets have to be multiplied together; also a term ab signifies that a is multiplied by b. The *rule of signs* which summarizes the foregoing conclusions in multiplication can be stated in the form: like signs give +, unlike signs give −.

Meaning of Brackets. If a number stands in front of a bracket as we have seen, it means that it has to be multiplied by whatever stands inside the bracket, even if the number inside is composed of several added or subtracted or multiplied. Thus:

$$\begin{array}{l} 5 \times 6 = 5(4 + 2) = 5 \times 4 + 5 \times 2 \\ 5(x + y) = 5 \times x + 5 \times y = 5x + 5y \\ a(x + y) = ax + ay. \end{array}$$

This notion can be extended at once to the case where the number that stands in front of the bracket is itself composed of several parts. Thus if we have $(a + b)(x + y)$ we can write it thus:

$$\begin{array}{rl} (a + b)(x + y) & = a(x + y) + b(x + y) \\ & = ax + ay + bx + by \end{array}$$

$$(a+b)(x-y) = a(x-y) + b(x-y)$$
$$= ax - ay + bx - by$$
$$(x+y)(x-y) = x(x-y) + y(x-y)$$
$$= x^2 - xy + yx - y^2.$$

Here we have written $x \times x$ as x^2 to be read x-squared just as we did with ordinary numbers. In the same way we write y^2 for $y \times y$. Now xy is the same as yx. It follows that: $(x+y)(x-y) = x^2 - y^2$.

Let us verify this by writing definite numbers for x and y, say $x = 10$, $y = 3$. Then

$$x+y = 10+3 = 13 \qquad x-y = 10-3 = 7$$
$$x^2 = 10^2 = 100 \qquad y^2 = 3^2 = 9$$

Thus the formula says that

$$13 \times 7 = 100 - 9 = 91,$$

which gives the factors of 91.

We can say therefore that the factors of $x^2 - y^2$ are $x + y$ and $x - y$.

Algebraic Powers. We have just introduced the notion of *powers* for algebraic symbols by writing:

$$x \times x = x^2 \text{ instead of } xx.$$

In the same way we write

x^3 for $x \times x \times x$, x^4 for $x \times x \times x \times x$,

and so on. A number so written above a symbol is called an *index* (plural indices).

The Rule of Indices. There are three rules.

(i) We write $x^m = x \times x \times x \ldots .\ m$ times.

Here x appears as a multiplier m times in succession.

In the same way $x^n = x \times x \times x \times \ldots\ n$ times

$$\text{Hence } x^m \times x^n = (x \times x \times x \times \ldots m \text{ times})$$
$$\times\ x(x \times x \times x \ldots n \text{ times})$$
$$= x \times x \times x \ \ldots\ (m+n) \text{ times} = x^{m+n}.$$

It is easy to verify in this way that

$$x^4 \times x^7 = x^{4+7} = x^{11}$$
$$x^5 \times x^8 = x^{5+8} = x^{13}.$$

Thus, to multiply two powers of the same number we take that number raised to the sum of the two previous powers.

(ii) Suppose m is greater than n. We write this statement symbolically thus: $m > n$. Then

$$\frac{x^m}{x^n} = \frac{x \times x \times x \ldots .\ m \text{ times}}{x \times x \times x \ldots .\ n \text{ times}}$$

Whatever value x has, some of the x's above will cancel out with some below. How many will do so? Evidently all the x's underneath, n of them, since there are more x's in the numerator, m being greater than n. Thus there will be left $m - n$ such x's on top while the denominator will be reduced to the product of a series of 1's.

Finally, therefore: $\dfrac{x^m}{x^n} = x^{m-n}$

Verification:

$$\frac{2^5}{2^3} = \frac{2 \times 2 \times 2 \times 2 \times 2}{2 \times 2 \times 2} = 2 \times 2 = 2^2 = 2^{5-3}$$

(iii) What of a power of a power of x? Suppose x^n is itself raised to the power m will the result still be a power of x?

$$(x^n)^m = x^n \times x^n \times x^n \times \ldots m \text{ times}$$

Thus:

$$(x^n)^m = x^{mn} = x^{nm} = (x^m)^n$$

Verification:

$$(x^3)^4 = x^3 \times x^3 \times x^3 \times x^3 = x^{3+3+3+3} = x^{12}$$

EXERCISES

(1) Find the value of $4p + 2s$ when $p = 20$, $s = 1$.

(2) Find the number of shillings in £4 2 0 and explain why the answer is the same as in question (1).

(3) Find the value of $2p + 17s + 6d$: (a) when $p = 240$, $s = 12$, $d = 1$ and (b) when $p = 20$, $s = 1$, $d = \frac{1}{12}$.

Compare the answers with the number of pence and the number of shillings respectively in £2 17 6.

(4) Add together

(a) $4a+7b+2c$, $a+3b+c$, $2a+b+6c$.

(b) $15x+17y$, $13x-4y$, $x+y$.

(c) $a+3b$, $a-b+2c$, $a-2c$.

(5) Simplify $(4p+6q-7r)+(p+q\times 2r)-(2p+q+r)$ and find its value if $p=3, q=-1, r=0$.

(6) How many ft. are there in 4 yds., 10 yds., x yds.?

(7) A rectangular table has sides of lengths p ft. and q ft. What is its area? What is the length of a side of a square table having the same area?

(8) A circle has a radius of r ft. What is the length of its circumference in inches and its area in square inches?

(9) Show that $(2a + b)(2a - b) = 4a^2 - b^2$ and verify this (a) when $a = 3$, $b = 1$ and (b) when $a = 3$, $b = 8$.

(10) Of a group of 15 men, x wear spectacles and 5 need spectacles but do not wear them. How many men of the group have good sight?

Answers to Exercises in Lesson 9

(1) 75 ft.

(2) 129·9 ft., 75 ft.

(3) Distance rowed = 130 yds., distance remaining = 2433⅓ yds.

(4) Sin 156° = 0·41, cos 156° = −0·91, tan 156° = −0·45. Sin 200° = −0·34, cos 200° = −0·94, tan 200° = 0·36. Sin 236° = −0·83, cos 236° = −0·56, tan 236° = 1·48. Sin 315° = −0·71, cos 315° = 0·71, tan 315° = −1.

(5) Sin 180° = 0, cos 180° = − 1, tan 180° = 0. Sin 270° = −1, cos 270° = 0, tan 270° is indefinitely large. Sin 360° = 0, cos 360° = 1, tan 360° = 0.

LESSON 11

The Idea of a Function

We are now in a position to consider a set of terms involving powers of x combined by additions, subtractions or multiplications. Here, for example, are some such expressions:

x^2+5x+4; x^3-7x^2+2x-1; x^4-16; x^7-x+5.

These are all called *functions* of x, of a special kind. In fact, any mathematical expression which involves x, and whose value therefore depends on the value assigned to x, is called a function of x. To put it in general terms, one quantity is said to be a function of another if a change in one correspondingly affects the other. It is usual to write $f(x)$ for the phrase 'function of x.' It means nothing more than what these words imply.

Systematic Arrangement in Powers of x. Consider this function, for example,

$$x - 7x^3 + 24 + 13x^4 - x^2.$$

The order in which the separate terms are added or subtracted does not affect its final value, of course, but for some purposes it is better to use one order rather than another. For example, if we were calculating its value for very large values of x we would be more interested in the higher powers of x than in the lower powers. We should write these first—like this:

$$13x^4 - 7x^3 - x^2 + x + 24.$$

This is written, for obvious convenience in calculations, in descending powers of x.

We should write it in this order if x were a large number like 1,000, for the first term would be 13,000,000,000,000 as compared with the last term which is only 24.

On the other hand, if we are interested in the lower powers rather than the higher powers we should write it in ascending powers of x—thus:

$$24 + x - x^2 - 7x^3 + 13x^4.$$

We would write it in this order if x were a small number like 0·001, for the first term is now 24 as compared with the last term, which is 0·000,000,000,013.

Addition and Subtraction of Functions. Such operations are much simplified if the terms are arranged as above. For example, if we have to add the functions $24 + x - x^2 - 7x^3 + 13x^4$ $5x - x^3 - 26$ and $5x^3 - 10x^4 - 12 + x^2$ we would write them one under the other in descending powers of x:

$$\begin{array}{lrrrrr}
 & 13x^4 & -\ 7x^3 & -\ x^2 & +\ x & +\ 24\\
 & & -\ x^3 & & +\ 5x & -\ 26\\
 & -10x^4 & +\ 5x^3 & +\ x^2 & & -\ 12\\
\hline
\text{Answer:} & 3x^4 & -\ 3x^3 & & +\ 6x & -\ 14
\end{array}$$

Care must be taken to put the terms with the same powers in the same column.

The same principle applies to subtraction:

$$\begin{array}{lrrrrr}
\text{From} & 13x^4 & -\ 7x^3 & -\ x^2 & +\ x & +\ 24\\
\text{take} & -10x^4 & +\ 5x^3 & +\ x^2 & & -\ 12\\
\hline
\text{Answer:} & 23x^4 & -\ 12x^3 & -\ 2x^2 & +\ x & +\ 36
\end{array}$$

Multiplication of Functions. When two expressions are multiplied together every item or term in the one is multiplied by every item or term in the other. Again this is best carried through by writing both functions in, say descending powers of x, and ensuring that each term found for the product is written in its appropriate column corresponding to its power of x We can explain this best by means of examples.

1. Multiply $x^2 - x + 1$ by $x^2 + x + 1$.

Write it in this way:

$$\begin{array}{rrrrrll}
 & & x^2 & -\ x & +\ 1 & \ldots\ldots\ldots & \text{(i)}\\
 & & x^2 & +\ x & +\ 1 & & \\
\hline
 & & x^2 & -\ x & +\ 1 & \ldots\ldots\ldots & \text{(ii)}\\
 & x^3 & -\ x^2 & +\ x & & \ldots\ldots\ldots & \text{(iii)}\\
x^4 & -\ x^3 & +\ x^2 & & & \ldots\ldots\ldots & \text{(iv)}\\
\hline
x^4 & & +\ x^2 & & +\ 1 & \ldots\ldots\ldots & \text{(v)}
\end{array}$$

Line (ii) is obtained by multiplying each item in line (i) by + 1, line (iii) by multiplying by x, and line (iv) by multiplying by x^2; since $1 + x + x^2$ is the multiplier. In the result each item is placed in the column corresponding to its appropriate power.

2. Multiply

$5x^4+10x^3+10x^2+5x+1$ by x^3-3x^2+3x+1

Again we set it out systematically as under:

$$\begin{array}{rrrrrrrr}
 & & & 5x^4 & +10x^3 & +10x^2 & +\ 5x & +1\\
 & & & & x^3 & -\ 3x^2 & +\ 3x & +1\\
\hline
 & & & 5x^4 & +10x^3 & +10x^2 & +\ 5x & +1\\
 & & 15x^5 & +30x^4 & +30x^3 & +15x^2 & +\ 3x & \\
 & -15x^6 & -30x^5 & -30x^4 & -15x^3 & -\ 3x^2 & & \\
5x^7 & +10x^6 & +10x^5 & +\ 5x^4 & +\ \ x^3 & & & \\
\hline
5x^7 & -\ 5x^6 & -\ 5x^5 & +10x^4 & +26x^3 & +22x^2 & +\ 8x & +1
\end{array}$$

Division of Functions. To divide $x^3 + 3x^2 + 4x + 2$ by $x^2 + 2x + 1$, for example, again it is necessary to set both terms out in the same way. Here, for illustration we carry the division through when the terms are arranged in descending powers of x, and then in ascending powers.

1. In descending powers of x.

$$\begin{array}{rl} x^2+2x+1) & x^3+3x^2+4x+2\,(x+1 \\ & \underline{x^3+2x^2+\ x} \\ & \phantom{x^3+{}}x^2+3x+2 \\ & \phantom{x^3+{}}\underline{x^2+2x+1} \\ & \phantom{x^3+x^2+{}}x+1 \end{array}$$

The first term x in the answer is found from the fact that x^2 is converted into x^3 by multiplying by x. The whole divisor $x^2 + 2x + 1$ is then multiplied by x and the result subtracted. The next term 2 is brought down and the divisor now requires only to be multiplied by 1. There is a remainder, $x + 1$.

2. The ascending powers of x.

$$\begin{array}{rl} 1+2x+x^2) & 2+4x+3x^2+x^3\,(2+x^2 \\ & \underline{2+4x+2x^2} \\ & \phantom{2+4x+{}}x^2+x^3 \\ & \phantom{2+4x+{}}\underline{x^2+2x^3+x^4} \\ & \phantom{2+4x+x^2+{}}-x^3\ -x^4 \end{array}$$

The answer, if we stop at this stage, is $2 + x^2$, and the remainder is $- x^3 - x^4$.

Numerical Verification. (i) In the first case choose $x = 10$, say, then:

$$x^2+2x+1=10^2+20+1=121$$
$$x^3+3x^2+4x+2=10^3+3\times10^2+40+2=1342$$
$$x+1=11$$

$$\text{Now } \frac{1342}{121} = 11$$

and the remainder is 11 as expected.

(ii) In the second case, choose $x = -0{\cdot}1$.

$$1+2x+x^2 = 1-0{\cdot}2+0{\cdot}01=0{\cdot}81$$
$$2+4x+3x^2+x^3 = 2-0{\cdot}4+0{\cdot}03-0{\cdot}001=1{\cdot}629$$
$$2 \quad + x^2 = 2+0{\cdot}01 = 2{\cdot}01$$

$$\text{Now} \quad \frac{1{\cdot}629}{0{\cdot}81} = 2{\cdot}01$$

and the remainder is 0·0009. But

$$- x^3 - x^4 = 0{\cdot}001 - 0{\cdot}0001 = 0{\cdot}0009$$

which is the remainder.

Here we see how each method of writing out the function corresponds to a method of division suitable for large or for small values of x respectively, because in each case the remainder becomes small in comparison with the numbers originally used in the division.

Algebraic Verification. We can easily show by direct multiplication that what we have found shows that

$$(x^2 + 2x + 1)(x + 1) + (x + 1)$$

and

$$(1 + 2x + x^2)(2 + x^2) - x^3 - x^4$$

are two ways of writing $x^3 + 3x^2 + 4x + 2$.

The first of these, moreover, indicates that since $(x + 1)$ appears in both terms, $x + 1$ must be a factor of $x^3 + 3x^2 + 4x + 2$.

Verify this by direct division showing that the result is $x^2 + 2x + 2$.

Functions of x and y. An expression depending for its value on the values assigned to two quantities x and y is called a function of two variables x and y. For example:

$$x^2 + 2xy + y^2$$
$$x^2 + 2x \quad + y - 5$$

are functions of this type. In such cases, instead of writing $f(x)$, we indicate the presence of the two variables by writing $f(x, y)$.

Degree of a Term. A term such as x^4 or y^4 is of degree 4. When x and y are both present in the same term, as for example in xy, or xy^3, or x^4y^2, the term is spoken of as of a degree equal to the sum of the two separate degrees. Thus, xy is of degree 2, xy^3 of degree 4, x^4y^2 of degree 6.

Of course, all the terms of a function of x and y are not necessarily of the same degree. When all the terms are of the same degree the function is said to be *homogeneous*.

For example, $x^3 + 3x^2y + 3xy^2 + y^3$ has all its terms of degree 3; it is therefore homogeneous.

Any function of x and y can be separated out into a series of groups each of which is a homogeneous function. For example:

$$x^6 + y^3 - 7x^2y + x^4y - x^3y^3 + y^5$$

can be rewritten in the form:

$$(x^6 - x^3y^3) + (x^4y + y^5) + (y^3 - 7x^2y)$$

in which the terms in brackets are respectively of degree 6, 5, 3.

Multiplication and Division of Functions of More than One Variable. The processes of addition, subtraction, multiplication and division can be carried through in this case in precisely the same way as for one variable. We fix on one of the variables, say x, and arrange the functions in descending or ascending powers of x. Thus, to divide

$$x^4+4x^3y+6x^2y^2+4xy^3+y^4 \text{ by } x+y$$

we write—

$$\begin{array}{l}
x+y)\,x^4+4x^3y+6x^2y^2+4xy^3+y^4\,(x^3+3x^2y+3xy^2+y^3 \\
\quad\underline{x^4+x^3y} \\
\qquad 3x^3y+6x^2y^2 \\
\qquad \underline{3x^3y+3x^2y^2} \\
\qquad\qquad 3x^2y^2+4xy^3 \\
\qquad\qquad \underline{3x^2y^2+3xy^3} \\
\qquad\qquad\qquad xy^3+y^4 \\
\qquad\qquad\qquad \underline{xy^3+y^4}
\end{array}$$

Answer : $\underline{x^3 + 3x^2y + 3xy^2 + y^3.}$

EXERCISES

(1) Verify that (a) $2^6 \times 2^3 = 2^9$, (b) $x^3 \times x^5 = x^8$, (c) $3^2 \times 3^4 \times 3 = 3^7$, (d) $8^2 = (2^3)^2 = 2^6$, (e) $5^6 \div (25)^2 = 25$, (f) $a^8 \times a^3 \div a^9 = a^2$, (g) $(2 \times 5)^3 = 2^3 \times 5^3$.

(2) A carpet has sides of length a ft., $a + 3$ ft. What is its area and the length of a diagonal ?

(3) Multiply the following expressions together :

(a) $7x^3 - x$ by $x^2 + 2x + 5$, (b) $x^2 - x + 1$ by $x^2 + 1$, (c) $4a + b - c + 2d$ by $a + 2c$, (d) $1 + a + a^2 + a^3$ by $1 - a$, (e) $x^2 + 4xy + 6y^2$ by $2xy$.

(4) Find n if 2^n is greater than 1,000 but less than 2,000.

(5) By taking numerical examples, verify that the terms $1, x, x^2, x^3, x^4, \ldots\ldots$ become smaller and smaller if $x < 1$, but increase if $x > 1$.

(6) Divide (a) $1 + x$ into $1 + x + x^2 + x^3$.
(b) $1 - x$ into $1 - x^5$.

(7) Show that

$$\frac{1+3x^2+4x^4}{1+x^2} = 1+2x^2+\frac{2x^4}{1+x^2} = 4x^2-1+\frac{2}{x^2+1}$$

(8) Divide $x^3 - 3x^2y + 3xy^2 - y^3$ by $x - y$.

(9) Show that $x^3 - y^3 = (x-y)\ (x^2+xy+y^2)$.

Answers to Exercises in Lesson 10

(1) 82. (2) 82.
(3) (a) 690, (b) $57\frac{1}{2}$.
(4) (a) $7a + 11b + 9c$, (b) $29x + 14y$, (c) $3a + 2b$.
(5) $3p + 6q - 6r$, 3. (6) 12, 30, $3x$.
(7) pq sq. ft., $\sqrt{(pq)}$ ft.
(8) $24\pi r$ in., $144\ \pi r^2$ sq. in.
(10) $10 - x$.

LESSON 12

Trigonometrical Functions of Compound Angles

In the last Lesson dealing with Trigonometry (Lesson 9), we extended our definitions of sine, cosine and tangent to include angles of any positive size, and we will now consider negative angles by adopting exactly the same reasoning as when considering negative numbers in arithmetic (Lesson 2). The distinction is between clockwise and anti-clockwise.

Negative Angles. The convention for measuring positive angles is to start from the positive x axis and rotate in an anti-clockwise direction. As is to be expected, *negative* angles are measured from the same initial line but rotating in the opposite direction, i.e. in a *clockwise* direction. As an example, consider an angle of 60° from which is subtracted 15° (Fig. 80). A rotation of 60° in a clockwise direction brings us to the position OA, then subtracting 15° we arrrive at OB. Notice that to arrive at OB we have rotated through 15° in a clockwise direction. We might have considered the angle 60° − 15° as 60° + (− 15°) which provides us immediately with the conception of a negative angle.

Thus we may consider negative angles independently, and consequently a negative angle having a numerical size less than 90° lies in the fourth quadrant, a negative angle between − 90° and − 180° in the third quadrant and so on. From these positions it is a simple matter to determine the trigonometrical ratios of negative angles in terms of positive angles ; for instance, $\sin(-A) = -\sin A$, $\cos(-A) = \cos A$ and $\tan(-A) = -\tan A$.

Example. Find the sine, cosine and tangent of − 120°.

From Fig. 81 it is clear that

$$\sin(-120^\circ) = \frac{NP_1}{OP_1} \text{ and } \sin(+120^\circ) = \frac{NP_2}{OP_2}$$

so that $\qquad \sin(-120^\circ) = -\sin(+120^\circ)$.

But $\quad \sin(120^\circ) = \sin 60^\circ = \sqrt{3}/2$

so that $\qquad \sin(-120^\circ) = -\sqrt{3}/2$.

Both $\cos(-120^\circ)$ and $\cos(+120^\circ)$ are equal to

$$\frac{ON}{OP_2}$$

i.e. $\cos(-120^\circ) = \cos(+120^\circ) = -\cos 60^\circ = -\frac{1}{2}$

and, finally,

$$\tan(-120^\circ) = \frac{NP_1}{ON} = -\tan(120^\circ)$$
$$= -(-\tan 60^\circ) = +\sqrt{3}.$$

Simplified Expressions for Angles involving 90°, 180°, etc. In trigonometrical work angles such as 180° − A, 90° + A, 360° − A are of very common occurrence, and it is important to be able to write the sines, cosines and tangents of these angles in as simple a form as possible, generally in terms of the angle A alone. If reference is made to Lesson 9, where angles greater than 90° were discussed, it will be seen how this may be done. We will illustrate with actual examples.

Example. Express the ratios of $180° - A$ in terms of those of A.

Fig. 82 represents the position of the angle $180° - A$ when A is less than 90°. From the figure it will be seen that $\sin (180° - A)$ is positive and numerically equal to $\sin A$. On the other hand $\cos (180° - A)$ is negative but numerically equal to $\cos A$, so that $\sin (180° - A) = \sin A$, $\cos (180° - A) = -\cos A$ and consequently $\tan (180° - A) = -\tan A$. In exactly the same way these relations can be proved true for *any* value of A.

Example. Express the ratios of $90° + A$ in terms of those of A only.

Fig. 83 shows the position of the revolving line OP for an angle $90° + A$, when A is less than 90°. If a perpendicular is drawn from P on to the x axis it will be seen that $\angle POY = A = \angle OPN$. The sine of $90° + A$ is given by $\frac{PN}{OP}$ which is positive and equal numerically to $\cos \angle OPN$, i.e. $\cos A$. Thus $\sin (90° + A) = \cos A$.

Similarly, $\cos (90° + A)$ is negative and numerically equal to $\sin \angle OPN$, i.e. $\sin A$, so that

$\cos (90° + A) = -\sin A$. Finally, then,
$\tan (90° + A) = -\cot A$.

All these relations may be proved equally true if A is greater than 90°.

Relations between the Angles of any Triangle. An immediate use of the foregoing is provided in finding the relations between the trigonometrical ratios of the angles of any triangle. For then, if the three angles are A, B, C, we have $A + B + C = 180°$, so that $A + B = 180° - C$. Therefore, from the preceding considerations,

$\sin (A + B) = \sin (180° - C) = \sin C$ and
$\cos (A + B) = \cos (180° - C) = -\cos C$
and finally, since
$\frac{1}{2}(A + B) = \frac{1}{2}(180 - C) = 90 - \frac{1}{2}C$,
$\sin \frac{1}{2}(A + B) = \sin (90 - \frac{1}{2}C) = \cos \frac{1}{2}C$.

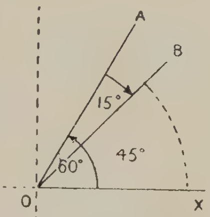


Fig 80

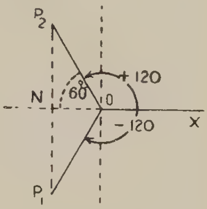


Fig 81

Fig. 80. Measuring negative angles clockwise. Fig. 81. Sin, cos and tan of −120 deg.

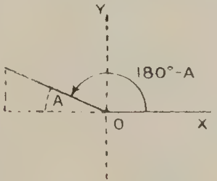


Fig 82

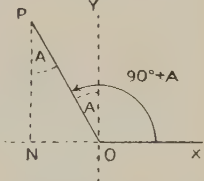


Fig 83

Figs. 82 and 83. Simple compound angles.

Note.—We have here used, for the first time, the expressions $\sin (A + B)$ and $\cos (A + B)$, and these mean exactly what they indicate: namely, the sine and cosine respectively of two angles added together. The reader must be careful not to make the error of thinking that $\sin (A + B)$ is equal to $\sin A + \sin B$. This is *not* true. There is no reason why it should be. The word 'sin' is in no sense a quantity which multiplies $A + B$, it simply denotes the *operation* of finding the sine of the combined angles $A + B$. Nevertheless, the sine of $(A + B)$ can be expanded in terms of $\sin A$, $\cos A$, $\sin B$ and $\cos B$, and it is this and similar expansions that we will now consider. First of all, in order to prove the various expansions we must consider the projections of lines in more detail.

Directed Lines. An important idea, useful in many branches of mathematics, is that of directed lines. We may choose one direction along a line as positive and then the opposite direction will be considered as negative; in fact we have already done this when defining co-ordinate axes. From left to right we chose as the positive x direction, so that from right to left was the negative x direction. Consider the four lines PQ in Fig. 84. The arrowhead indicates their direction; in every case perpendiculars have been drawn on to a horizontal

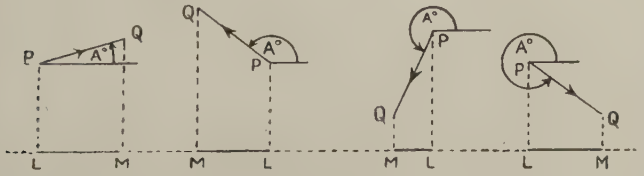


Fig 84

DIRECTED LINES. Fig. 84. Showing the directed line P Q with projections L M.

line so that LM is the *projection* of each line on to this line. In each case the projection is PQ cos A, and, taking from left to right as a positive direction, we see from the diagram that in the first and last cases the projection is positive, but in the second and third it is negative. Finally, we may notice (Fig. 85) that if any triangle PQR is drawn, the projection of PQ = the projection of PR + the projection of RQ, i.e. LN = LM + MN. This is quite in order because MN is itself negative.

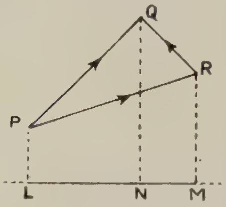


Fig. 85

To Prove $\cos(A+B)=\cos A\cos B-\sin A\sin B$ and $\sin(A+B)=\sin A\cos B+\cos A\sin B$.

Take any angle A and add to it an angle B (Fig. 86). On the boundary line of this combined angle choose any point P and draw a perpendicular PN on to the boundary line of the angle A, and produce to Q.

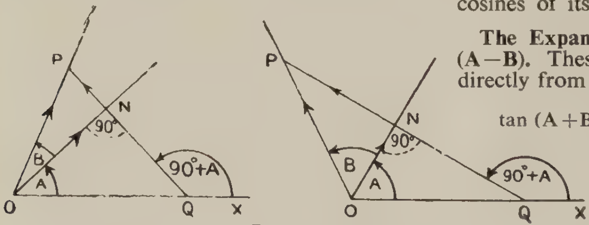


Fig. 86

Fig. 86. ***Proving relations in compound angles by projection.***

(Two cases are drawn, but the following proof will be found to be true, whatever values are given to A and B.) Thus we have a triangle ONP, and so, projecting this triangle on to OX we have:

$$\text{projection OP} = \text{projection ON} + \text{projection NP} \quad . \; . \; . \; . \; . \qquad (i)$$

The projection of OP on to OX is OP cos (A + B) and since △ ONP is right-angled ON = OP cos B and NP = OP sin B.

Thus the relation (i) becomes

$$\begin{aligned}OP\cos(A+B) &= ON\cos A+NP\cos\angle XQP\\ &= OP\cos B\cos A+OP\sin B\cos\angle XQP\\ &= OP\cos B\cos A+OP\sin B\cos(90+A)\end{aligned}$$

since $\angle XQP=90°+A$; also $\cos(90+A)=-\sin A$, so that

$$OP\cos(A+B)=OP\cos B\cos A-OP\sin B\sin A$$

or $$\cos(A+B)=\cos A\cos B-\sin A\sin B \quad . \; . \; . \; . \; . \; . \qquad (ii)$$

In exactly the same way, by projecting the triangle ONP on to a line at right angles to OX we obtain

$$\sin(A+B)=\sin A\cos B+\cos A\sin B \quad . \; . \qquad (iii)$$

The Expansion for sin (A−B) and cos (A−B). We may obtain these expansions most easily by replacing B by − B in (ii) and (iii). Thus, from (ii)

$$\cos(A+(-B))=\cos A\cos(-B)-\sin A\sin(-B)$$

and as we have seen earlier,

$$\cos(-B)=\cos B \text{ and } \sin(-B)=-\sin B,$$

so that

$$\cos(A-B)=\cos A\cos B+\sin A\sin B \qquad (iv)$$

Again, from (iii)

$$\sin(A+(-B))=\sin A\cos(-B)+\cos A\sin(-B)$$

i.e. $$\sin(A-B)=\sin A\cos B-\cos A\sin B \qquad (v)$$

These four expansions, (ii), (iii), (iv) and (v), are of extreme importance and should be memorized. They provide the means of breaking up the sine or cosine of a combined angle into the sines and cosines of its constituent parts.

The Expansion for tan (A + B) and tan (A−B). These expansions may be obtained directly from what we now know, for

$$\tan(A+B)=\frac{\sin(A+B)}{\cos(A+B)}$$
$$=\frac{\sin A\cos B+\cos A\sin B}{\cos A\cos B-\sin A\sin B}$$

and dividing numerator and denominator of this last expression by cos A cos B we obtain

$$\tan(A+B)=\frac{\tan A+\tan B}{1-\tan A\tan B} \quad . \; . \; . \; . \qquad (vi)$$

Again we may replace B by − B in order to obtain tan (A − B); thus

$$\tan(A+(-B))=\frac{\tan A+\tan(-B)}{1-\tan A\tan(-B)}$$

i.e. $$\tan(A-B)=\frac{\tan A-\tan B}{1+\tan A\tan B} \quad . \qquad (vii)$$

The reader should verify that this can be obtained equally well by dividing the expansion for sin (A − B) by that for cos (A − B).

We will now work out some examples, using the expansions we have obtained.

Example. Find the value of cos 15°.

Since 15° = 60° − 45° we may use the expansion for cos (A−B) to determine cos 15° in terms of the sine and cosine of 60° and 45°; thus:

$$\begin{aligned}\cos 15^\circ &= \cos (60^\circ - 45^\circ)\\ &= \cos 60^\circ \cos 45^\circ + \sin 60^\circ \sin 45^\circ\\ &= \frac{1}{2}\cdot\frac{1}{\sqrt{2}} + \frac{\sqrt{3}}{2}\cdot\frac{1}{\sqrt{2}}\\ &= \frac{1+\sqrt{3}}{2\sqrt{2}}.\end{aligned}$$

Example. To prove by expansion that $\cos (90^\circ + A) = -\sin A$.

$$\begin{aligned}\cos (90^\circ + A) &= \cos 90^\circ \cos A - \sin 90^\circ \sin A.\\ &= 0 \cdot \cos A - 1 \cdot \sin A\\ &= -\sin A.\end{aligned}$$

Example. Find the expansion of $\cot (A+B)$ in terms of $\cot A$ and $\cot B$.

$$\begin{aligned}\cot (A+B) &= \frac{1}{\tan (A+B)} = \frac{1-\tan A \tan B}{\tan A + \tan B}\\ &= \left\{1 - \frac{1}{\cot A}\cdot\frac{1}{\cot B}\right\} \Big/ \left\{\frac{1}{\cot A} + \frac{1}{\cot B}\right\}\\ &= \frac{\cot A \cot B - 1}{\cot A + \cot B}\end{aligned}$$

by multiplying numerator and denominator by $\cot A \cot B$.

Example. Show that, in any triangle ABC, $\sin A = \sin B \cos C + \cos B \sin C$.

As we have seen in an earlier paragraph, since $A+B+C = 180^\circ$, $B+C = 180^\circ - A$, so that $\sin (B+C) = \sin (180^\circ - A) = \sin A$

$$\begin{aligned}\text{i.e.}\qquad \sin A &= \sin (B+C)\\ &= \sin B \cos C + \cos B \sin C.\end{aligned}$$

Sin 2A, cos 2A and tan 2A. A very important application of the foregoing expansions occurs when $B = A$. Then, for instance, $\sin (A + B) = \sin (A + A)$, i.e. $\sin (2A)$, and since no ambiguity arises, this is written $\sin 2A$ and it simply means the sine of an angle 2A in size. By replacing B by A in each of the expansions $\sin (A+B)$, $\cos (A + B)$ and $\tan (A + B)$ we obtain the following:

$$\begin{aligned}(1)\ \sin 2A &= \sin A \cos A + \cos A \sin A\\ &= 2 \sin A \cos A \quad \ldots\ldots\ldots \quad (viii)\\ (2)\ \cos 2A &= \cos A \cos A - \sin A \sin A\\ &= \cos^2 A - \sin^2 A \quad \ldots\ldots\ldots \quad (ix)\\ (3)\ \tan 2A &= \frac{\tan A + \tan A}{1 - \tan A\ .\ \tan A}\\ &= \frac{2 \tan A}{1-\tan^2 A} \quad \ldots\ldots \quad (x)\end{aligned}$$

These three relations should also be memorized as they are of frequent occurrence in further mathematical work. It should be noticed that since they are independent of the size of the angle A, we may, by writing $2A = P$, obtain the sine, cosine and tangent of any angle in terms of its half-angle. Thus, if

$$2A = P, \text{ then } A = \tfrac{1}{2}P$$

and we obtain

$$\sin P = 2 \sin \tfrac{1}{2}P \cos \tfrac{1}{2}P,\quad \cos P = \cos^2 \tfrac{1}{2}P - \sin^2 \tfrac{1}{2}P$$

and

$$\tan P = \frac{2 \tan \frac{1}{2}P}{1 - \tan^2 \frac{1}{2}P}.$$

Relation (ix) should be especially noticed as it is capable of alternative forms since $\sin^2 A + \cos^2 A = 1$. Thus:

$$\begin{aligned}\cos 2A &= \cos^2 A - \sin^2 A\\ &= \cos^2 A - (1 - \cos^2 A)\\ &= 2 \cos^2 A - 1 \quad \ldots\ldots \quad (xi)\end{aligned}$$

or, alternatively

$$\begin{aligned}\cos 2A &= \cos^2 A - \sin^2 A\\ &= (1 - \sin^2 A) - \sin^2 A\\ &= 1 - 2 \sin^2 A \quad \ldots\ldots \quad (xii)\end{aligned}$$

From these relations we may obtain $\sin^2 A$ and $\cos^2 A$ in terms of $\cos 2A$. For example (xi) may be rewritten

$$\begin{aligned}2 \cos^2 A &= 1 + \cos 2A\\ \text{i.e.}\qquad \cos^2 A &= \tfrac{1}{2}(1 + \cos 2A)\end{aligned}$$

and from (xii)

$$\sin^2 A = \tfrac{1}{2}(1 - \cos 2A).$$

In more advanced work it will be necessary to change expressions involving the powers of sin A and cos A into forms only containing multiples of A, and it is then that the usefulness of these relations will become evident.

The Expansions for Three Angles. We can obtain the expansion of expressions such as $\sin (A + B + C)$, $\tan (A - B + C)$, where the three angles may all be independent (i.e. not necessarily the angles of a triangle), by using expansions (ii) to (vii) and keeping two angles together in the first instance. We illustrate with an actual example:

$$\begin{aligned}\sin (A+B+C) &= \sin (A + (B+C))\\ &= \sin A \cos (B+C) + \cos A \sin (B+C)\\ &= \sin A\ (\cos B \cos C - \sin B \sin C)\\ &\qquad + \cos A\ (\sin B \cos C + \cos B \sin C)\\ &= \sin A \cos B \cos C + \cos A \sin B \cos C\\ &\qquad + \cos A \cos B \sin C - \sin A \sin B \sin C \quad (xiii)\end{aligned}$$

by re-arrangement. Notice particularly the symmetry of this expression; the first three terms each contain the product of two cosines and a sine, the last term is the product of the three sines. The expansion for an expression such as $\sin (A - B + C)$ is obtained by replacing B by $-B$ in (xiii), thus:

$$\begin{aligned}\sin(A-B+C) &= \sin A\cos(-B)\cos C+\cos A\sin(-B)\cos C+\cos A\cos(-B)\sin C\\ &\quad -\sin A\sin(-B)\sin C\\ &=\sin A\cos B\cos C-\cos A\sin B\cos C\\ &\quad +\cos A\cos B\sin C+\sin A\sin B\sin C.\end{aligned}$$

By a similar method we can obtain the expansions for $\cos(A+B+C)$, $\tan(A+B+C)$ and so on.

From relation (xiii) we may obtain the expansion for $\sin 3A$ by putting $B=C=A$ as follows:

$$\begin{aligned}\sin 3A &= \sin A\cos^2 A+\cos A\sin A\cos A\\ &\quad +\cos A\cos A\sin A-\sin A\sin A\sin A\\ &=3\sin A\cos^2 A-\sin^3 A\\ &=3\sin A(1-\sin^2 A)-\sin^3 A\\ &=3\sin A-4\sin^3 A.\end{aligned}$$

Of course, if $\sin 3A$ is required in the first instance, there is no need to work through the expansion of $\sin(A+B+C)$. It may be found directly by writing $\sin 3A=\sin(A+2A)$ and then expanding.

EXERCISES

(1) Find the values of $\sin(-225°)$, $\tan(-45°)$, $\cos(-330°)$.

(2) By drawing quadrant diagrams, simplify $\sin(180°+A)$, $\cot(180°+A)$, $\cos(360°-A)$, $\operatorname{cosec}(360°+A)$ and check the results obtained by expansion.

(3) From a table of values of sines and cosines, verify that $\sin 48°=2\sin 24°\cos 24°$.

(4) By writing $\sin 75°$ as $\sin(45°+30°)$ and expanding, prove that $\sin 75°=(\sqrt{6}+\sqrt{2})/4$.

(5) Prove that $\sin(A+B)+\cos(A-B)=(\sin A+\cos A)(\sin B+\cos B)$. By replacing B by $-B$, deduce the factors of $\sin(A-B)+\cos(A+B)$.

(6) Obtain the expansion of $\cos(A+B+C)$ and from it deduce (1) the expansion of $\cos(B+C-A)$ and (2) that $\cos 3A=4\cos^3 A-3\cos A$.

(7) Express $\tan(A+B+C)$ in terms of $\tan A$, $\tan B$ and $\tan C$. Deduce that $\tan 3A=(3\tan A-\tan^3 A)/(1-3\tan^2 A)$ and verify by expanding $\tan(A+2A)$ directly.

(8) If A, B, C are the angles of a triangle, show that

(1) $\cos A=\sin B\sin C-\cos B\cos C$,
(2) $\sin\frac{1}{2}A=\cos\frac{1}{2}B\cos\frac{1}{2}C-\sin\frac{1}{2}B\sin\frac{1}{2}C$,
(3) $\tan A+\tan B+\tan C=\tan A\tan B\tan C$.

Answers to Exercises in Lesson 11

(2) $a(a+3)$ sq. ft., $\sqrt{(2a^2+6a+9)}$ ft.

(3) (a) $7x^5+14x^4+34x^3-2x^2-5x$.
(b) $x^4-x^3+2x^2-x+1$.
(c) $4a^2+ab+7ac+2ad+2bc+4cd-2c^2$.
(d) $1-a^4$.
(e) $2x^3y+8x^2y^2+12xy^3$.

(4) 10.

(6) (a) $1+x^2$.
(b) $1+x+x^2+x^3+x^4$.

(8) $x^2-2xy+y^2$.

LESSON 13

Trigonometrical Identities

We have already indicated that the transformation of trigonometrical expressions into equivalent expressions of a different form plays an important part in the usefulness of trigonometry in more advanced mathematics, and we will now consider some more fundamental transformations.

Transformation of Products and Sums. These may be obtained directly from the expansions of the last Lesson. Consider those for $\sin(A+B)$ and $\sin(A-B)$; namely

$$\sin(A+B)=\sin A\cos B+\cos A\sin B \quad . \; (i)$$

and

$$\sin(A-B)=\sin A\cos B-\cos A\sin B \quad . \; . \; (ii)$$

By adding these two we obtain

$$\sin(A+B)+\sin(A-B)=2\sin A\cos B \quad . \; . \; (iii)$$

and by subtracting (ii) from (i)

$$\sin(A+B)-\sin(A-B)=2\cos A\sin B \quad . \; . \; (iv)$$

Notice what these last two relations imply: that the product of the sine of one angle and the cosine of another can be expressed as the sum or difference of two sines. We may proceed similarly with the expansions for the cosines; thus:

$$\cos(A+B)=\cos A\cos B-\sin A\sin B \quad . \; . \; (v)$$

and

$$\cos(A-B)=\cos A\cos B+\sin A\sin B \quad . \; . \; (vi)$$

Adding (v) to (vi)

$$\cos(A+B)+\cos(A-B)=2\cos A\cos B \quad . \; (vii)$$

and subtracting (v) from (vi)

$$\cos(A-B)-\cos(A+B)=2\sin A\sin B \quad . \; (viii)$$

In this case it is desirable to subtract $\cos(A+B)$ from $\cos(A-B)$ in order to obtain a form on the right-hand side with a positive expression. This is because the cosine of any angle is greater than the cosine of a larger angle. The relations (vii) and (viii) give expressions for the product of two cosines and of two sines as the sum and difference of two cosines respectively.

If we wish to use relations (iii), (iv), (vii) and (viii) to express the sum or difference of two sines or cosines as products, they are more conveniently put in a slightly modified form: if we represent the angle $A + B$ by a single term C and the angle $A-B$ by a term D, then we have $A+B=C$, $A-B=D$, so that adding and subtracting, $2A=C+D$ and $2B=C-D$, i.e. $A=\frac{1}{2}(C+D)$ and $B=\frac{1}{2}(C-D)$. Then (iii) may be written:

$$\sin C+\sin D=2\sin\tfrac{1}{2}(C+D)\cos\tfrac{1}{2}(C-D) \quad \ldots (ix)$$

From (iv)

$$\sin C-\sin D=2\cos\tfrac{1}{2}(C+D)\sin\tfrac{1}{2}(C-D) \quad \ldots (x)$$

from (vii)

$$\cos C+\cos D=2\cos\tfrac{1}{2}(C+D)\cos\tfrac{1}{2}(C-D) \quad . (xi)$$

and from (viii)

$$\cos D-\cos C=2\sin\tfrac{1}{2}(C+D)\sin\tfrac{1}{2}(C-D) \quad . (xii)$$

Some examples will serve to show how these transformations are applied.

Example. Express as products: (1) $\sin 3A + \sin A$; (2) $\cos 5A - \cos A$; (3) $\sin 34° - \sin 14°$; (4) $\sin 20° + \cos 60°$.

(1) From (ix)

$$\begin{aligned}\sin 3A+\sin A&=2\sin\tfrac{1}{2}(3A+A)\cos\tfrac{1}{2}(3A-A)\\&=2\sin 2A\cos A\end{aligned}$$

(2) Relation (xii) might equally well have been written

$$\cos C-\cos D= -2\sin\tfrac{1}{2}(C+D)\sin\tfrac{1}{2}(C-D)$$

and we can use this to transform $\cos 5A - \cos A$, for then

$$\begin{aligned}\cos 5A-\cos A&= -2\sin\tfrac{1}{2}(5A+A)\sin\tfrac{1}{2}(5A-A)\\&= -2\sin 3A\sin 2A\end{aligned}$$

(3) Using relation (x)

$$\begin{aligned}\sin 34°-\sin 14°&=2\cos\tfrac{1}{2}(34°+14°)\\&\qquad\sin\tfrac{1}{2}(34°-14°)\\&=2\cos 24°\sin 10°.\end{aligned}$$

The reader is advised to take this example and verify it by working out both sides from a set of tables of sine and cosine; there will be a very slight discrepancy due to the fact that the tables give only approximate values, correct to four places of decimals.

(4) No relation which we have obtained gives the sum of a sine and a cosine as a product; for that we must first express either $\sin 20°$ as a cosine or alternatively $\cos 60°$ as a sine. Remembering that $\cos A = \sin(90°-A)$ we obtain

$$\begin{aligned}\sin 20°+\cos 60°&=\sin 20°+\sin(90°-60°)\\&=\sin 20°+\sin 30°\\&=2\sin\tfrac{1}{2}(20°+30°)\\&\qquad\cos\tfrac{1}{2}(30°-20°)\\&=2\sin 25°\cos 5°.\end{aligned}$$

Example. Express as a sum or difference of two trigonometrical ratios (1) $2\sin 4\theta\cos\theta$, (2) $\sin 3\theta\sin\theta$, (3) $2\sin\frac{1}{2}A\cos\frac{1}{2}A$.

(1) Relation (iii) is

$$2\sin A\cos B=\sin(A+B)+\sin(A-B)$$

so that $2\sin 4\theta\cos\theta=\sin(4\theta+\theta)+\sin(4\theta-\theta)$

$$= \sin 5\theta+\sin 3\theta$$

(2) The product of two sines was expressed as a difference of two cosines; namely:

$$2\sin A\sin B=\cos(A-B)-\cos(A+B)$$

Thus

$$\begin{aligned}\sin 3\theta\sin\theta&=\tfrac{1}{2}(\cos(3\theta-\theta)-\cos(3\theta+\theta))\\&=\tfrac{1}{2}(\cos 2\theta-\cos 4\theta)\end{aligned}$$

(3) From relation (iii)

$$\begin{aligned}2\sin\tfrac{1}{2}A\cos\tfrac{1}{2}A&=\sin(\tfrac{1}{2}A+\tfrac{1}{2}A)+\sin(\tfrac{1}{2}A-\tfrac{1}{2}A)\\&=\sin A+\sin 0°\\&=\sin A\end{aligned}$$

It will be remembered that this was obtained when $\sin A$ was expanded in terms of $\frac{1}{2}A$.

Example. Show that

$$\cos 3A\sin 2A-\cos 2A\sin A= \cos 4A\sin A.$$

From (iv) $\cos 3A\sin 2A=\frac{1}{2}(\sin 5A-\sin A)$

and $\cos 2A\sin A=\frac{1}{2}(\sin 3A-\sin A)$

so that

$$\begin{aligned}\cos 3A&\sin 2A-\cos 2A\sin A\\&=\tfrac{1}{2}(\sin 5A-\sin A-\sin 3A+\sin A)\\&=\tfrac{1}{2}(\sin 5A-\sin 3A)\\&=\tfrac{1}{2}.2\cos 4A\sin A \quad . . . \text{ from (x)}\\&=\cos 4A\sin A.\end{aligned}$$

Identities. Consider the two relations $\sin^2 A+\cos^2 A=1$ and $\sin A=1$. They are of very different types. The first of these is *true for all values of A* and is said to be an *identity*; but the second relation, i.e. $\sin A=1$, is only true for special values of A, namely, 90°, 360°+90°, 720°+90°, . . . and so on, and is said to be a *trigonometrical equation.* We have already explained that the study of identities is very important in more advanced work; it is imperative to be able to manipulate a trigonometrical expression into different equivalent forms. The study of trigonometrical equations we will leave until a later Lesson.

It will now be realized that all the expansions and transformations we have obtained are examples of identities; the expression to one side of the 'equals' sign being equivalent to that on the other side of the 'equals,' but expressed in a different form.

It is unfortunate that the same sign (=) is generally used for both, although an attempt is sometimes made to overcome this difficulty by using the symbol ≡ between the two parts of an identity. An identity is generally most conveniently proved by taking one side and showing by successive transformations that it is equivalent to the other side, although it may sometimes be necessary to work with both sides and show that they are both equivalent to the same expression. We shall denote the left-hand side by L.H.S. and the right-hand side by R.H.S.

We will now work out some examples of simple identities, using the fundamental relations obtained in Lesson 8 (pp. 205–208).

Example. Prove that $3-4\sin^2 A=4\cos^2 A-1$

$$\begin{aligned}\text{L.H.S.}&=3-4\sin^2 A\\&=3-4(1-\cos^2 A) \text{ since } \sin^2 A+\cos^2 A = 1\\&=3-4+4\cos^2 A\\&=\text{R.H.S.}\end{aligned}$$

Example. Prove that $\cos^2 A(1+3\tan^2 A) = 1+2\sin^2 A$

$$\begin{aligned}\text{L. H. S.} &= \cos^2 A(1+3\tan^2 A)\\ &= \cos^2 A + 3\cos^2 A\cdot\frac{\sin^2 A}{\cos^2 A} \text{ since } \tan A = \frac{\sin A}{\cos A},\\ &= \cos^2 A + 3\sin^2 A\\ &= (1-\sin^2 A) + 3\sin^2 A\\ &= 1+2\sin^2 A\\ &= \text{R.H.S.}\end{aligned}$$

Example. Prove that $\sin^4 A - \cos^4 A = \sin^2 A - \cos^2 A$.

It will be remembered from the algebra that $x^2-y^2=(x-y)\ (x+y)$ and if we put $x=\sin^2 A$ and $y=\cos^2 A$ this will mean that $\sin^4 A-\cos^4 A=(\sin^2 A-\cos^2 A)(\sin^2 A+\cos^2 A)$ and $\sin^2 A+\cos^2 A=1$, so that

$$\sin^4 A - \cos^4 A = \sin^2 A - \cos^2 A.$$

Example. Prove the identity

$$\frac{\cos A}{1+\sin A}+\frac{1+\sin A}{\cos A}=\frac{2}{\cos A}.$$

By taking a common denominator of $\cos A\ (1+\sin A)$ we may write

$$\begin{aligned}\text{L.H.S.} &= \frac{\cos^2 A + (1+\sin A)^2}{\cos A\ (1+\sin A)}\\ &= \frac{\cos^2 A + 1 + 2\sin A + \sin^2 A}{\cos A\ (1+\sin A)}\\ &= \frac{2+2\sin A}{\cos A\ (1+\sin A)} \text{ since } \cos^2 A + \sin^2 A = 1\\ &= \frac{2\ (1+\sin A)}{\cos A\ (1+\sin A)}\\ &= \text{R.H.S.}\end{aligned}$$

Identities involving the manipulation of expressions such as sin 2A, sin 4A, cos 2A will be valuable in later work. We give two examples.

Example. If $t = \tan \frac{1}{2}A$, show that (1) $\sin A = 2t/(1+t^2)$, (2) $\cos A = (1-t^2)/(1+t^2)$

(1) From Lesson 12 we may write

$$\begin{aligned}\sin A &= 2\sin \tfrac{1}{2}A.\ \cos \tfrac{1}{2}A\\ &= 2\frac{\sin \frac{1}{2}A}{\cos \frac{1}{2}A}\cdot \cos^2 \tfrac{1}{2}A\end{aligned}$$

multiplying numerator and denominator by $\cos \frac{1}{2}A$

$$\begin{aligned}&= \frac{2t}{\sec^2 \frac{1}{2}A} \text{ since } \cos^2 \tfrac{1}{2}A = \frac{1}{\sec^2 \frac{1}{2}A}.\\ &= \frac{2t}{1+t^2} \text{ since } \sec^2 \tfrac{1}{2}A = 1 + \tan^2 \tfrac{1}{2}A\end{aligned}$$

(2) Similarly

$$\begin{aligned}\cos A &= \cos^2 \tfrac{1}{2}A - \sin^2 \tfrac{1}{2}A\\ &= \cos^2 \tfrac{1}{2}A.\ \left(1-\frac{\sin^2 \frac{1}{2}A}{\cos^2 \frac{1}{2}A}\right)\\ &= \cos^2 \tfrac{1}{2}A.\ (1-t^2)\\ &= \frac{1-t^2}{1+t^2} \text{ as in example (1).}\end{aligned}$$

Example. Show that $\cos^2 2A - \sin^2 A = \frac{1}{2}(\cos 4A + \cos 2A)$.

We have already obtained (in Lesson 12, p. 221) the expansion of cos 2A as

$$\cos 2A = 2\cos^2 A - 1$$

hence, on replacing A by 2A

$$\cos 4A = 2\cos^2 2A - 1$$

i.e. $\quad 2\cos^2 2A = 1 + \cos 4A.$

Since also $\cos 2A = 1 - 2\sin^2 A$ as an alternative form, then

$$2\sin^2 A = 1 - \cos 2A$$

i.e.

$$\begin{aligned}\cos^2 2A - \sin^2 A &= \tfrac{1}{2}(1+\cos 4A) - \tfrac{1}{2}(1-\cos 2A)\\ &= \tfrac{1}{2}(\cos 4A + \cos 2A)\end{aligned}$$

Again, we may use the transformations of products and sums obtained earlier in this Lesson to prove the equivalence of identical forms. In fact, we have already proved such an identity as an example of the use of the transformations, and we will now include a few more examples to illustrate them further.

Example. Prove that

$$2\sin A\ (\cos A + \cos 3A + \cos 5A + \cos 7A) = \sin 8A.$$

To prove this identity we need the expression

$$2\sin B\cos A = \sin(A+B) - \sin(A-B).$$

Thus:

$$\begin{aligned}&2\sin A\cos A = \sin 2A - \sin 0,\\ \text{also}\quad &2\sin A\cos 3A = \sin 4A - \sin 2A\\ \text{and}\quad &2\sin A\cos 5A = \sin 6A - \sin 4A.\\ \text{Again}\quad &2\sin A\cos 7A = \sin 8A - \sin 6A.\end{aligned}$$

If we add these four expressions together, the left-hand side is $2\sin A\cos A + 2\sin A\cos 3A + 2\sin A\cos 5A + 2\sin A\cos 7A$, which is the L.H.S. of our given identity. On adding the R.H.S. it will be seen that all the terms cancel except sin 8A in the last line. Thus we have proved the identity.

Notice that the process could have been continued indefinitely; it is a very simple matter to generalize it. We should then have $2\sin A\ (\cos A + \cos 3A + \cos 5A + \ldots + \cos (2n-1)\ A) = \sin (2nA)$, where we have taken the last term of the L.H.S. as $\cos (2n-1)$ A, since $2n-1$ is always odd and can be made equal to any odd number by suitably choosing n. This extension of our original identity provides us with a means of finding the sum of a set of cosine terms where the angles are odd multiples of A; for the above relation may be rearranged as

$$\cos A + \cos 3A + \ldots + \cos (2n-1)\ A = \frac{\sin (2nA)}{2\sin A}$$

We will end this Lesson with two examples of identities of a slightly different type, both of which are concerned with three angles A, B and C which add up to 180°, i.e. they may be considered as being the angles of a triangle. This in no way conflicts with what we have stated concerning identities; A, B and C are not tied down to particular values, they may be of any size, but subject to the over-riding condition that $A + B + C = 180°$.

Example. If $A + B + C = 180°$, prove that
$\sin 2A + \sin 2B + \sin 2C = 4 \sin A \sin B \sin C$

L.H.S. $= \sin 2A + \sin 2B + \sin 2C = 2 \sin (A+B) \cos (A-B) + \sin 2C$

by transforming the sum of sin 2A and sin 2B into a product,

$= 2 \sin (A+B) \cos (A-B) + 2 \sin C \cos C$

by expanding sin 2C. Now, as seen in Lesson 12, if $A + B + C = 180°$

then $A + B = 180° - C$, so that

$\sin (A+B) = \sin C$ and $\cos (A+B) = -\cos C$

i.e. L.H.S. $= 2 \sin C \cos (A-B) - 2 \sin C \cos (A+B)$

$= 2 \sin C (\cos (A-B) - \cos (A+B))$

$= 2 \sin C . 2 \sin \frac{1}{2}(A-B+A+B) \sin \frac{1}{2}(A+B-A+B)$

$= 4 \sin C \sin A \sin B$

= R.H.S.

Example. If $A+B+C=180°$, prove that $\sin A + \sin B + \sin C = 4 \cos \frac{1}{2}A \cos \frac{1}{2}B \cos \frac{1}{2}C$.

We shall be dealing here with the half angles of A, B and C and so we shall have the following relations: since $A+B+C=180°$, $A+B=180°-C$, i.e. $\frac{1}{2}(A+B) = 90° - \frac{1}{2}C$.

Thus $\sin \frac{1}{2}(A+B) = \sin (90 - \frac{1}{2}C) = \cos \frac{1}{2}C$
and $\cos \frac{1}{2}(A+B) = \cos (90 - \frac{1}{2}C) = \sin \frac{1}{2}C$.

Returning now to the identity to be proved, we obtain

L.H.S. $= \sin A + \sin B + \sin C$

$= 2 \sin \frac{1}{2}(A+B) \cos \frac{1}{2}(A-B) + 2 \sin \frac{1}{2}C \cos \frac{1}{2}C$

by transforming sin A + sin B into a product and expanding sin C exactly as in the last example

$= 2 \cos \frac{1}{2}C \cos \frac{1}{2}(A-B) + 2 \cos \frac{1}{2}(A+B) \cos \frac{1}{2}C$

in virtue of the relations above

$= 2 \cos \frac{1}{2}C (\cos \frac{1}{2}(A-B) + \cos \frac{1}{2}(A+B))$

$= 2 \cos \frac{1}{2}C . 2 \cos \frac{1}{4}(A-B+A+B) \cos \frac{1}{4}(A+B-A+B)$

$= 4 \cos \frac{1}{2}C . \cos \frac{1}{2}A \cos \frac{1}{2}B$

= R.H.S.

EXERCISES

(1) Express as products $\sin 3A - \sin A$, $\cos 3A + \cos A$, $\sin 2A + \sin 2B$, $\cos 15° - \cos 59°$, $\sin 72° - \cos 30°$.

(2) Express as the sum or difference of two trigonometrical ratios $2 \sin 5A \cos A$, $2 \sin A \sin 3A$, $\sin 2A \cos 2B$, $2 \sin (A-B) \cos (A+B)$, $\cos 70° \cos 30°$.

(3) Prove the following identities:

(i) $\sin A \tan A \cos A = 1 - \cos^2 A$
(ii) $\cos^2 A (\tan^2 A - \sin^2 A) = \sin^4 A$
(iii) $\sin^2 A + 4 = 5 - \cos^2 A$
(iv) $(1 - \sin A)(1 + \sin A) = \cos^2 A$
(v) $1 + \cot A = \cot A (1 + \tan A)$

(4) If $t = \tan \frac{1}{2}A$, using the expressions obtained in an example for sin A and cos A in terms of t, show that

(i) $\dfrac{\sin A + \cos A + 1}{\sin A - \cos A + 1} = t$
(ii) $\sec A + \tan A = (1+t)/(1-t)$

(5) Prove that $\tan A = \dfrac{\sin A + \sin 2A}{1 + \cos A + \cos 2A}$

(6) Prove the following identities:

(i) $\dfrac{\sin A + \sin 3A + \sin 5A}{\cos A + \cos 3A + \cos 5A} = \tan 3A$
(ii) $\cos A + \cos B + \cos C + \cos(A+B+C) = 4 \cos \frac{1}{2}(B+C) \cos \frac{1}{2}(C+A) \cos \frac{1}{2}(A+B)$.

(7) By writing sin 5A as $\sin (2A + 3A)$ and expanding, find sin 5A in terms of powers of sin A only.

(8) From the identity $2 \cos^2 A = \cos 2A + 1$, multiplying both sides by 2 cos A, show that

$$4 \cos^3 A = \cos 3A + 3 \cos A.$$

By repeating the process, find $8 \cos^4 A$ and $16 \cos^5 A$ in terms of the cosines of multiples of A only.

(9) If $A+B+C=180°$, show that

(i) $\cos 2A + \cos 2B + \cos 2C = -1 - 4 \cos A \cos B \cos C$
(ii) $\sin^2 A + \sin^2 B + \sin^2 C = 2 (1 + \cos A \cos B \cos C)$
(iii) $\cos^2 A + \cos^2 B + \cos^2 C = 1 - 2 \cos A \cos B \cos C$
(iv) $\cos A + \cos B + \cos C = 1 + 4 \sin \frac{1}{2} A \sin \frac{1}{2} B \sin \frac{1}{2} C$.

Answers to Exercises in Lesson 12

(1) $1/\sqrt{2}$, -1, $\sqrt{3}/2$.
(2) $-\sin A$, $\cot A$, $\cos A$, $\operatorname{cosec} A$.
(5) $(\cos A + \sin A)(\cos B - \sin B)$.
(6) $\cos (A + B + C) = \cos A \cos B \cos C - \cos A \sin B \sin C - \cos B \sin C \sin A - \cos C \sin A \sin B$
$\cos (B + C - A) = \cos A \cos B \cos C - \cos A \sin B \sin C + \cos B \sin C \sin A + \cos C \sin A \sin B$.
(7) $\tan (A+B+C) = \dfrac{\tan A + \tan B + \tan C - \tan A \tan B \tan C}{1 - \tan A \tan B - \tan B \tan C - \tan C \tan A}$.

LESSON 14

Indices and Logarithms

We have already considered the fundamental law of algebra known as the Index Law. In Lesson 10 we showed that if m and n were two positive integers. then

$$a^{m} \times a^{n} = a^{m+n}$$

and this can be immediately extended to any number of terms ; for

$$a^{m} \times a^{n} \times a^{p} \times \ \ldots = a^{m+n} \times a^{p} \times \ \ldots$$
$$= a^{m+n+p+} \ldots$$

Now, the property of algebra which distinguishes it from arithmetic is that in algebra numbers are represented by letters. This means that if a result is obtained in terms of letters, it will be equally true if the letters are replaced by any numbers, providing that during the course of the algebraic work no restrictions were placed on the numbers which the letters could represent. Thus, the above laws concerning indices are very much hampered in their application by the fact that m and n were of necessity positive integers. For instance, the index law may need to be used in a piece of algebraic work in which there is no means of knowing in advance whether the indices are positive or not. Accordingly an attempt is made to arrange that the above index laws shall be true for *all* values of m and n ; that is, positive, negative and fractional values of m and n. No help in this connexion is obtained by considering what is to be meant by $a \times a \times a \times \ldots$ to a negative or fractional number of terms and so the problem is attacked another way. We ask the question : can a meaning be found for a^{m} when m is negative or fractional so that the above laws shall still hold ? If we can find such a meaning then we shall be entitled to say that with this meaning the index laws will hold for *all* values of m and n. We will first take a particular example and attempt to find a meaning for, say, $2^{\frac{1}{3}}$.

If the index law is to hold,

$$2^{\frac{1}{3}} \times 2^{\frac{1}{3}} \times 2^{\frac{1}{3}} = 2^{\frac{1}{3}+\frac{1}{3}+\frac{1}{3}} = 2^{1}$$

$$\therefore \quad (2^{\frac{1}{3}})^{3} = 2$$

and taking cube roots of both sides we have that $2^{\frac{1}{3}}$ means $\sqrt[3]{2}$. This can be very easily generalized ; if n is a positive integer, then $\frac{1}{n}$ is a positive fraction and

$$a^{\frac{1}{n}} \times a^{\frac{1}{n}} \times a^{\frac{1}{n}} \times \ \ldots \text{ to } n \text{ factors}$$
$$= a^{\frac{1}{n}+\frac{1}{n}+\frac{1}{n}} \ \ldots \text{ to } n \text{ terms}$$
$$= a^{n(\frac{1}{n})}$$
$$= a$$

i.e. $\left(a^{\frac{1}{n}}\right)^{n} = a$

and taking the n^{th} root of both sides $a^{\frac{1}{n}}$ means $\sqrt[n]{a}$.

At this stage it is convenient to derive a meaning for a^{0}, still subject to the condition that the index law shall hold ; thus $a^{3} \times a^{0}$ is to equal a^{3+0}, i.e. a^{3}, so that a^{0} must equal $\frac{a^{3}}{a^{3}}$ i.e. 1, which says that any number raised to the power zero is to be given the meaning 1. We can use this to derive a meaning for a negative index for example

$$2^{3} \times 2^{-3} = 2^{3-3} = 2^{0} = 1$$

Therefore, dividing both sides by 2^{3}, 2^{-3} must mean $\frac{1}{2^{3}}$ and this can be generalized so that a^{-m} means $\frac{1}{a^{m}}$.

Finally, consider $4^{3/2}$

$$4^{3/2} = 4^{\frac{1}{2}+\frac{1}{2}+\frac{1}{2}}$$
$$= 4^{\frac{1}{2}} \times 4^{\frac{1}{2}} \times 4^{\frac{1}{2}} \text{ (if the Index Law holds)}$$
$$= (4^{\frac{1}{2}})^{3}$$

and therefore

$$4^{3/2} \text{ means } (\sqrt{4})^{3} \text{ i.e. } 2^{3}, \text{ or } 8,$$

but alternatively since then

$$4^{3/2} \times 4^{3/2} = 4^{3/2+3/2} = 4^{3}$$

then $\qquad (4^{3/2})^{2} = 4^{3}$

so that $4^{3/2}$ can be considered as the square root of 4^{3}, i.e.

$4^{3/2}$ means $\sqrt{4^{3}}$ i.e. $\sqrt{64}$ or 8.

Thus

$$4^{3/2} = (4^{3})^{\frac{1}{2}} = (4^{\frac{1}{2}})^{3}$$

A few examples are now added to illustrate these extensions of the Index Law.

Example. Evaluate $3 \,.\, 2^{-2} + 8 \,.\, 4^{-1} + 16^{-\frac{1}{2}}$

$$\text{This expression} = 3 \cdot \frac{1}{2^{2}} + 8 \cdot \frac{1}{4} + \frac{1}{16^{\frac{1}{2}}}$$
$$= \frac{3}{4} + \frac{8}{4} + \frac{1}{\sqrt{16}}$$
$$= \tfrac{3}{4} + 2 + \tfrac{1}{4}$$
$$= 3$$

Example. Multiply $2^{\frac{3}{4}} \,.\, 3^{\frac{1}{2}}$ by 18

$$\begin{aligned} 18 \times 2^{\frac{3}{4}}\, 3^{\frac{1}{2}} &= 2 \times 3^2 \times 2^{\frac{3}{4}} \times 3^{\frac{1}{2}} \\ &= 2^{1+\frac{3}{4}} \times 3^{2+\frac{1}{2}} \\ &= 2^{\frac{7}{4}} 3^{\frac{5}{2}} \end{aligned}$$

Example. Simplify $(x^{-4}\, y^{\frac{3}{5}})^{-5}$

$$\begin{aligned} (x^{-4}\, y^{\frac{3}{5}})^{-5} &= x^{(-4)(-5)}\, y^{\frac{3}{5}(-5)} \\ &= x^{20}\, y^{-3} \\ &= \frac{x^{20}}{y^3} \end{aligned}$$

Example. Simplify $\dfrac{ab(b^{-1}-a^{-1})}{a-b} + \dfrac{a-b}{b^{-1}-a^{-1}}$

$$\begin{aligned} \text{This expression} &= \frac{ab}{a-b}\left(\frac{1}{b} - \frac{1}{a}\right) + \frac{a-b}{\frac{1}{b}-\frac{1}{a}} \\ &= \frac{ab}{a-b}\left(\frac{a-b}{ab}\right) + \frac{(a-b)ab}{a-b} \\ &= 1 + ab \end{aligned}$$

We have already seen that a^m is capable of an intelligible meaning when m is a fraction, but the cases we have considered so far have been very simple. The meaning we have derived for a^m when m is *any* fraction is such that we obtain intelligible meanings for a^m for *all* fractional values of m, and it is often convenient to consider these fractional values in their decimal forms. Thus, for example, $5^{\frac{273}{1000}}$ means the thousandth root of 5^{273}, or alternatively $(\sqrt[1000]{5})^{273}$ and may be written $5^{0{\cdot}273}$.

It is worth while remembering the different kinds of decimals which can exist. Consider the three decimals 0·125, $3{\cdot}\dot{6}$, 3·141 . . . . . . The first of these is the exact decimal equivalent of the fraction $\frac{1}{8}$; the second is a recurring decimal and means 3·6666 . . . . continuing indefinitely but, nevertheless, representing exactly $3\frac{2}{3}$. The decimal 3·141 . . . indicates that it represents a number greater than 3·141, but less than 3·142.

Even so, there are two possibilities; it may represent the first four figures of an exact decimal, for example, 3·14125, or it may represent the first four figures of the numerical value of what is termed an *incommensurable* quantity, that is, a quantity whose numerical value cannot be exactly determined, the decimal equivalent continuing indefinitely without recurrence. Many such quantities occur, one will have already been encountered, namely π, the numerical value of which is 3·14159 . . . . .

When an incommensurable quantity occurs in an expression to be evaluated, an approximation must be made and the approximate value to take must depend on the accuracy desired in the result. π is often approximated to 22/7, or more accurately 3·1416.

We are now in a position to consider a very important application of the index laws considered earlier in this chapter, namely, logarithms. By means of the theory which we shall establish, the amount of labour involved in the working out of numerical results can be very much reduced; multiplication being replaced by addition and division replaced by subtraction.

Definition of Logarithms. Suppose that a^m, when evaluated for a particular value of a and m, has a numerical value represented by N; then m is said to be the *logarithm* of N to the base a (written $\log_a$N). This simply means that if m is the power to which a (termed the *base*) is raised in order that $a^m = \text{N}$, then m is the logarithm of N, i.e. if $a^m = \text{N}$, then $m = \log_a \text{N}$.

For example, since $2^3 = 8$, then $3 = \log_2 8$.
Again, since $16^{0{\cdot}25} = 2$, then $0{\cdot}25 = \log_{16} 2$, and since $10^{-2} = 0{\cdot}01$, then $-2 = \log_{10} 0{\cdot}01$, and lastly $(\frac{1}{2})^4 = \frac{1}{16}$, so that $4 = \log_{\frac{1}{2}} (\frac{1}{16})$.

The definition of a logarithm is conveniently expressed by the formula:

$$\text{number} = (\text{base})^{\text{logarithm}}$$

Example. Find $\log_9 (27\sqrt{3})$

Let $x = \log_9 (27\sqrt{3})$

Then from the definition of a logarithm,

$$9^x = 27\sqrt{3}$$

i.e. $(3^2)^x = 27\sqrt{3} = 3^3 \cdot 3^{\frac{1}{2}} = 3^{\frac{7}{2}}$

i.e. $3^{2x} = 3^{\frac{7}{2}}$

$\therefore$ $2x = \frac{7}{2}$, equating the indices of 3.

Thus $x = \frac{7}{4}$ so that $\log_9 (27\sqrt{3}) = 1{\cdot}75$.

We will now consider the properties of logarithms which make them especially useful in computational work.

Properties of Logarithms.

1. The logarithm of 1 to any base is 0.

Since, from the theory of indices, a^0 had to be given the meaning 1, whatever the value of a, i.e. $a^0 = 1$, it follows from the definition of a logarithm that 0 is $\log_a 1$, i.e. the logarithm of 1 to any base is 0.

II. The logarithm of the base itself is 1

$$\begin{aligned} \text{Since } a^1 &= a \\ \text{Then } \log_a a &= 1 \end{aligned}$$

III. The logarithm of a product to any base is the *sum* of the logarithms of the factors to the same base. Let M × N represent a product whose logarithm to any base (a) is required; and suppose that M is equal to 'a' raised to a power m, and N is 'a' raised to a power n, then

$$M = a^m \text{ and } N = a^n$$

$\therefore\ m = \log_a M$ and $n = \log_a N$

Also $M \times N = a^m \times a^n = a^{m+n}$

i.e. $M \times N$ is equal to 'a' raised to the power $(m+n)$

This means that $(m+n)$ is the logarithm of $(M \times N)$ to base a, i.e.

$$\begin{aligned}\log_a (M \times N) &= m+n\\ &= \log_a M + \log_a N\end{aligned}$$

This is extendable to any number of factors, for

$$\begin{aligned}\log_a (M \times N \times P) &= \log_a (MN \times P)\\ &= \log_a (MN) + \log_a P\\ &= \log_a M + \log_a N + \log_a P,\end{aligned}$$

and so on.

Thus, for example,

$$\begin{aligned}\log_{10} 42 &= \log_{10} (2 \times 3 \times 7)\\ &= \log_{10} 2 + \log_{10} 3 + \log_{10} 7\end{aligned}$$

IV. The logarithm of a quotient is the logarithm of the denominator subtracted from the logarithm of the numerator. where the logarithms are taken to any base providing it is the same throughout, i.e.

$$\log_a \left(\frac{M}{N}\right) = \log_a M - \log_a N$$

The proof is similar to that of property III.

If $M = a^m$ and $N = a^n$, then $m = \log_a M$ and $n = \log_a N$.

Also $\dfrac{M}{N} = \dfrac{a^m}{a^n} = a^{m-n}$

so that $\log_a \left(\dfrac{M}{N}\right) = m - n = \log_a M - \log_a N$

As an example,

$$\begin{aligned}\log_3 (2\tfrac{1}{7}) &= \log_3 (\tfrac{15}{7})\\ &= \log_3 15 - \log_3 7\\ &= \log_3 (3 \times 5) - \log_3 7\\ &= \log_3 3 + \log_3 5 - \log_3 7\\ &= 1 + \log_3 5 - \log_3 7.\end{aligned}$$

V. The logarithm of a number (M) raised to a power (p) is p multiplied by the logarithm of the number,

i.e. $\log_a (M^p) = p \log_a M$

To prove this, let $M = a^m$ and therefore as before, $m = \log_a M$. Then

$$M^p = (a^m)^p = a^{pm}$$

i.e. M^p is equal to the base raised to a power (pm) so that $pm = \log_a (M^p)$

$$\begin{aligned}\text{i.e } \log_a (M^p) &= p \times m\\ &= p \times \log_a M\end{aligned}$$

Thus, for instance: $\log_{10} 81 = \log_{10} (3^4)$
$= 4 \log_{10} 3$

This could also have been seen from property III, because—

$$\begin{aligned}\log_{10}(3^4) &= \log_{10} (3 \times 3 \times 3 \times 3)\\ &= \log_{10} 3 + \log_{10} 3 + \log_{10} 3 + \log_{10} 3\\ &= 4 \log_{10} 3\end{aligned}$$

Example. Express $\log \left(\dfrac{r^5 s^{-\frac{1}{2}}}{\sqrt[3]{r}}\right)$ in terms of $\log r$ and $\log s$ (the logarithms to be taken to any base).

From the extended laws of indices

$$\begin{aligned}\frac{r^5 s^{-\frac{1}{2}}}{\sqrt[3]{r}} &= \frac{r^5 s^{-\frac{1}{2}}}{r^{\frac{1}{3}}}\\ &= r^{5-\frac{1}{3}}\ s^{-\frac{1}{2}}\\ &= r^{\frac{14}{3}}\ s^{-\frac{1}{2}}\end{aligned}$$

$$\begin{aligned}\therefore\quad \log_a \frac{r^5 s^{-\frac{1}{2}}}{\sqrt[3]{r}} &= \log_a (r^{\frac{14}{3}} s^{-\frac{1}{2}})\\ &= \log_a (r^{\frac{14}{3}}) + \log_a (s^{-\frac{1}{2}})\\ &= \tfrac{14}{3} \log_a r - \tfrac{1}{2} \log_a s\end{aligned}$$

where we have taken logarithms to any base (a).

Example. Show that $\log_a b \times \log_b a = 1$

Let $\log_a b = x$, then from the definition of a logarithm, $a^x = b$. Taking the xth root of both sides

$$a = b^{\frac{1}{x}}$$

$$\text{i.e.}\quad \frac{1}{x} = \log_b a$$

$$\therefore \log_a b \times \log_b a = x \cdot \frac{1}{x} = 1$$

Example. Given $\log_{10} 2 = 0{\cdot}30103$, to find $\log_4 25$.

Let $\log_4 25 = x$

Then $4^x = 25$

or multiplying both sides by 4

$$\begin{aligned}4.4^x &= 100\\ \text{i.e.}\quad 4^{x+1} &= 100\\ \text{or}\quad (2^2)^{x+1} &= 10^2\\ \text{i.e.}\quad 2^{2x+2} &= 10^2\end{aligned}$$

Taking logarithms of both sides to base 10

$$\begin{aligned}\log_{10}(2^{2x+2}) &= \log_{10}(10^2)\\ \text{or}\quad (2x+2) \log_{10} 2 &= 2 \log_{10} 10\\ &= 2\end{aligned}$$

$$\begin{aligned}\text{so that}\quad 2x+2 &= \frac{2}{\log_{10} 2}\\ &= \frac{2}{0{\cdot}30103}\\ \text{i.e.}\quad x+1 &= \frac{1}{0{\cdot}30103} \quad \text{on dividing both sides by 2}\\ &= 3{\cdot}32193\\ \text{i.e.}\quad x &= 2{\cdot}32193\end{aligned}$$

EXERCISES

(1) Multiply
  (i) $x^2 + x^{-2}$ by $x^2 - x^{-2}$,
  (ii) $x^{\frac{3}{2}} + x^{-\frac{1}{2}}$ by $x^{\frac{3}{2}} + x^{\frac{1}{2}}$,
  (iii) $a^{\frac{4}{3}} + 2a^{\frac{2}{3}}b^{\frac{4}{3}} + 4b^{\frac{8}{3}}$ by $a^{\frac{2}{3}} - 2b^{\frac{4}{3}}$.

(2) Evaluate
  (i) $(x^{-\frac{3}{2}})^{-2} \times (x^{-\frac{1}{2}})^2$ if $x = 1{\cdot}5$,
  (ii) $(2y)^{-4} \times x^{-3} \times (x^y)^{x^2}$ if $x = 2,\ y = 3$.
  (iii) $2^{x^2} - (2^x)^2$ if $x = 3$.

(3) Show that, if the index law is to hold for fractional indices, that $a^{h/k}$ means either $\sqrt[k]{a^h}$ or $(\sqrt[k]{a})^h$ where h, k are positive integers. Evaluate $9^{\frac{5}{2}}$ in both forms and show that the result is 243.

(4) Find the least integral value of n such that $(\frac{1}{2})^n < 0{\cdot}01$.

(5) Given $x^{\frac{1}{2}} = 3{\cdot}1623$, $x^{\frac{1}{4}} = 1{\cdot}7784$, $x^{\frac{1}{8}} = 1{\cdot}3335$, $x^{\frac{1}{16}} = 1.1549$, $x^{\frac{1}{32}} = 1{\cdot}076$, calculate to four figures $x^{\frac{5}{32}}$, $x^{\frac{7}{16}}$, $x^{0.625}$, $x^{-0.25}$.

(6) Find the values of $\log_8 128$, $\log_6 \frac{1}{216}$ $\log_a(a^6)$.

(7) Show that

(i) $\log_{10}(13\frac{1}{3}) = 1 + \log_{10}4 - \log_{10}3$,

(ii) $\log_3(9 \times 27) = 5$,

(iii) $\log_2(8\sqrt{8}) = 4{\cdot}5$,

(iv) $\log_{10}(100\sqrt{10}) = 2{\cdot}5$.

(8) Find a, b, c given that $\log_3 a = 2$, $\log_{10} b = -3$, $\log_4 c = \frac{1}{2}$.

(9) Given $\log_{10}2 = 0{\cdot}30103$, find $\log_{10}64$.

(10) Show that, to any base,

(i) $\log\,[(27^{\frac{1}{2}})\ (14^{-4}).\sqrt[3]{56}] = \frac{3}{2}\log 3 - \frac{11}{3}\log 7 - 3\log 2$,

(ii) $\log\,[(2x)^3\ y^{\frac{3}{2}}\ \sqrt{8xy}] = \frac{9}{2}\log 2 + \frac{7}{2}\log x + 2\log y$.

Answers to Exercises in Lesson 13

(1) 2 cos 2A sin A, 2 cos 2A cos A, 2 sin (A+B) cos (A−B), 2 sin 37° sin 22°, 2 cos 66° sin 6°.

(2) sin 6A + sin 4A, cos 2A − cos 4A, $\frac{1}{2}$ sin (2A+2B) + $\frac{1}{2}$ sin (2A−2B), sin 2A − sin 2B, $\frac{1}{2}$ cos 100° + $\frac{1}{2}$ cos 40°.

(7) $16\sin^5 A - 20\sin^3 A + 5\sin A$.

(8) $8\cos^4 A = \cos 4A + 4\cos 2A + 3$,
$16\cos^5 A = \cos 5A + 5\cos 3A + 10\cos A$.

LESSON 15

Application of Logarithms: The Slide Rule

In the last Lesson we dealt with the properties arising out of the definition of a logarithm, and it will have been noticed that these properties are quite independent of the number chosen as base. However, in the applications of logarithms which result from these properties, the base plays an important part and we will now consider the two most useful bases.

First, logarithms play an essential part in computational work, i.e. in the working out of numerical expressions and for this purpose the base 10 is most suitable. Some computational work, such as multiplication and division, is often very greatly simplified by using logarithms, whilst other work, such as finding a root of a numerical expression, is often impracticable without their aid. Logarithms to base 10 are called *Common Logarithms.*

Secondly, in theoretical algebra and in the various further branches of mathematics based on this algebra, logarithms are calculated to a different base. This base is denoted by the letter x and is an incommensurable quantity having the value 2·71828 . . . to five places of decimals. Logarithms calculated to this base are called *Natural or Naperian Logarithms.*

Their usefulness and necessity will become apparent only at a later stage of our work. For the present we shall confine our attention to common logarithms, i.e. to base 10.

Logarithms to Base 10. Consider 10^3 as an example of 10 raised to a simple power. This equals 1,000 and, therefore, from the definition of a logarithm, $\log_{10}1000 = 3$. In a similar manner we can draw up a table of a few powers of 10 and their corresponding logarithms as follows:

$$\begin{aligned} 10^0 &= 1, &\therefore\ \log_{10}1 &= 0;\\ 10^1 &= 10, &\therefore\ \log_{10}10 &= 1;\\ 10^2 &= 100, &\therefore\ \log_{10}100 &= 2;\\ 10^3 &= 1000, &\therefore\ \log_{10}1000 &= 3.\end{aligned}$$

In this table we have considered only integral powers of 10 and thus the logarithms obtained were whole numbers. Now consider $10^{1.5}$. From the theory of indices

$$\begin{aligned} 10^{1.5} &= 10^{1+\frac{1}{2}} = 10.10^{\frac{1}{2}} = 10\sqrt{10}\\ &= 10 \times 3{\cdot}1623\ .\ . = 31{\cdot}623\ .\ .\end{aligned}$$

Thus,

$$\log_{10} 31{\cdot}623\ .\ . = 1{\cdot}5,$$

and we have as a result found in this case that the logarithm of a number between 10 and 100 has a value between 1 and 2. Had we considered $10^{2.5}$, we would have found that $10^{2.5} = 100\sqrt{10} = 316{\cdot}23$ . . . so that here we have a number between 100 and 1,000 whose logarithm is between 2 and 3. It is obvious that we shall obtain a general rule, that numbers between 1 and 10 have logarithms between 0 and 1, numbers between 10 and 100 have logarithms between 1 and 2, between 100 and 1,000 logarithms between 2 and 3, and so on.

Thus any logarithm is conveniently split up into two parts; the whole number which is called the *characteristic*, and the decimal part which is called the *mantissa*. Thus, for every number between 10 and 100 the characteristic is 1, but the mantissa will vary and it is these mantissae which have been tabulated and form the logarithm tables so useful in computational work.

Turn to such a set of tables and consider how we may use them to find the logarithm of any number. In the left-hand column the numbers range from 10 up to 99. Along the top of the page are the numbers 0, 1, 2, ... 9, each one at the top of a column of four figures and then farther across the page is a second set of numbers 1 to 9. (Sometimes headed 'Fourth Figure' or 'Mean Differences'.) Remember that numbers in this table give mantissae only.

Consider some actual examples: To find the logarithms of 42, 42·6, 42·67 from the tables. In each of these cases, since the numbers are between 10 and 100 the characteristic is 1. From the tables look down the extreme left-hand column until the number 42 is reached (*see* page 231.) In this row, but in the next column (i.e., that headed 0) is found the mantissa 6232. Thus

$$\begin{aligned}\log_{10} 42{\cdot}0 &= +1+0{\cdot}6232\\ &= 1{\cdot}6232.\end{aligned}$$

The row across the top of the page gives the third figure so that continuing along the row opposite 42 until we come to the column headed 6, we find the mantissa 6294. This, then, gives the mantissa for 42·6, i.e., $\log_{10}42{\cdot}6=1{\cdot}6294$. If the logarithm of a number containing four figures is required, the additional part of the mantissa for the 'fourth figure' is found from the section 1 to 9 in the end columns of the page (i.e., those which may be headed 'Mean Differences'). Thus, to find $\log_{10}42{\cdot}67$, first find $\log_{10}42{\cdot}6$ as above (i.e., 1·6294) and then add on to the last place of decimals the amount in the same row but under the column 7, i.e., 7. Thus

$$\begin{aligned}\log_{10}42{\cdot}67 &= 1{\cdot}6294+0{\cdot}0007\\ &= 1{\cdot}6301\end{aligned}$$

Now, suppose we require the logarithm of 426. This number equals $10\times42{\cdot}6$, so that

$$\begin{aligned}\log_{10}426 &= \log_{10}10+\log_{10}42{\cdot}6\\ &= 1+1{\cdot}6294 \text{ (from the above)}\\ &= 2{\cdot}6294\end{aligned}$$

Notice that the only difference between $\log_{10}42{\cdot}6$ and $\log_{10}426$ is in the characteristic; the *mantissa is the same*. Again,

$$\begin{aligned}\text{since } 4260 &= 1000\times4{\cdot}26\\ \log_{10}4260 &= \log_{10}1000+\log_{10}4{\cdot}26\\ &= +3+0{\cdot}6294\\ &= 3{\cdot}6294.\end{aligned}$$

As an example of the further use of this method, consider the following table and the logarithms which it provides:

$$\begin{aligned}4260 &= 1000 \times 4{\cdot}26\\ 426 &= 100 \times 4{\cdot}26\\ 42.6 &= 10 \times 4{\cdot}26\\ 4{\cdot}26 &= 1 \times 4{\cdot}26\\ 0{\cdot}426 &= 10^{-1}\times 4{\cdot}26\\ 0{\cdot}0426 &= 10^{-2}\times 4{\cdot}26\end{aligned}$$

Therefore:

$$\begin{aligned}\log_{10} 4260 &= +3+0{\cdot}6294\\ \log_{10} 426 &= +2+0{\cdot}6294\\ \log_{10} 42{\cdot}6 &= +1+0{\cdot}6294\\ \log_{10} 4{\cdot}26 &= +0+0{\cdot}6294\\ \log_{10} 0{\cdot}426 &= -1+0{\cdot}6294\\ \log_{10} 0{\cdot}0426 &= -2+0{\cdot}6294\end{aligned}$$

and so on. Thus we have passed from numbers whose logarithms involve positive characteristics to those whose logarithms have negative characteristics. Note that logarithms of all numbers less than 1 have negative characteristics. Consider the last one. $\text{Log}_{10}0{\cdot}0426=-2+0{\cdot}6294$, i.e., the mantissa is still positive, but the characteristic is -2. The fact that only this integer is negative is indicated by writing $\log_{10}0{\cdot}0426 = \bar{2}{\cdot}6294$. The minus sign is placed over the 2 and is read as 'bar two.'

How to Construct a Logarithmic Table. Before we show the value of a logarithmic table for calculations it is desirable to give some idea of how such a table can be constructed. It is now clear that we require only the logarithms of numbers lying between 1 and 10, for the logarithms of all other numbers can be derived from these. Now we know that $10^0 = 1$, $10^{0{\cdot}5} = \sqrt{10} = 3{\cdot}1623 \ldots$ and $10^1 = 10$. Hence $10^{\cdot25} = \sqrt{3{\cdot}1623} = 1{\cdot}778 \ldots$ and $10^{\cdot125} = \sqrt{1{\cdot}778 \ldots} = 1{\cdot}33 \ldots$

Again

$$\begin{aligned}10^{\cdot375} &= 10^{\cdot25}\times10^{\cdot125} = 1{\cdot}778 \ldots \times 1{\cdot}33 = 2{\cdot}371 \ldots\\ 10^{\cdot625} &= 10^{\cdot5}\times10^{\cdot125} = 3{\cdot}1623\times1{\cdot}33 \ldots = 4{\cdot}216\\ 10^{\cdot75} &= 10^{\cdot5}\times10^{\cdot25} = 3{\cdot}1623\times1{\cdot}778 \ldots = 5{\cdot}623\\ 10^{\cdot875} &= 10^{\cdot75}\times10^{\cdot125} = 5{\cdot}623\times1{\cdot}33 \ldots = 7{\cdot}497\end{aligned}$$

Already, therefore, we have the following items for a logarithm table:

Logarithm of 1 = 0
,, ,, 1·33 . . = 0·125
,, ,, 1·778 . . = 0·250
,, ,, 2·371 . . = 0·375
,, ,, 3·162 . . = 0·500
,, ,, 4·216 . . = 0·625
,, ,, 5·623 . . = 0·750
,, ,, 7·497 . . = 0·875
,, ,, 10 = 1·000

Number	0	1	2	3	4	5	6	7	8	9	Fourth figure								
											1	2	3	4	5	6	7	8	9
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	6	10	13	16	19	23	26	29
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15	18	21	24	27
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14	17	20	22	25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3	5	7	11	13	16	18	21	24
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6	8	9	10	11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6	7	9	10	11
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6	7	8	10	11
37	5682	5694	5705	5717	5729	5740	5762	5763	5775	5786	1	2	3	5	6	7	8	9	10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6	7	8	9	10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	5	7	8	9	10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5	6	8	9	10
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5	6	7	8	9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5	6	7	8	9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5	6	7	8	9
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5	6	7	8	9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5	6	7	8	9
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5	6	7	7	8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5	5	6	7	8
48	6812	6821	6830	6839	6846	6857	6866	6875	6884	6893	1	2	3	4	4	5	6	7	8
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4	5	6	7	8

Portions of a Table of Logarithms including calculations in page 230.

A simple way of extending this table is to draw a graph of the above logarithms against the numbers of which they are the logarithms, and read off intermediate values from this graph. The ordinary logarithm table is, of course, calculated in a much more elaborate way and with much greater accuracy than we have taken. For our purpose, however, it suffices to show that such a table can be constructed.

Let us consider the way in which the logarithm tables can be used in working out an actual computation.

Example. In this case we shall use only the table we have constructed above. To evaluate $x = 1\cdot778 \times 4\cdot216$.

Now the logarithm of a product is the sum of the logarithms of the factors. Thus

$$\begin{aligned}\log x &= \log 1\cdot778 + \log 4\cdot216\\ &= 0\cdot250 + 0\cdot625 \text{ from the above table}\\ &= 0\cdot875\end{aligned}$$

Again from this table $\log 7\cdot497 = 0\cdot875$

Hence $1\cdot778 \times 4\cdot216 = 7\cdot497 \ldots$

as accurately as our tables will allow.

For subsequent examples reference should be made to a 4-figure logarithmic table.

Example. Evaluate $\dfrac{138\cdot7\times0\cdot037}{36\cdot9}$

From the properties of logarithms already established

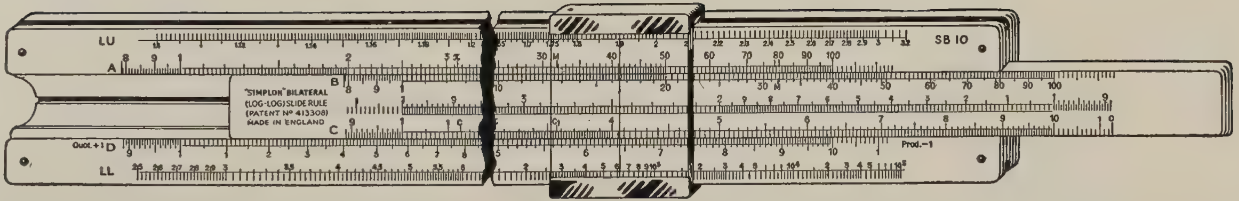
$$\begin{aligned}\log_{10}\frac{138\cdot7\times0\cdot037}{36\cdot9} &= \log_{10}138\cdot7+\log_{10}0\cdot037\\ &\quad -\log_{10}36\cdot9\\ &= 2\cdot1422+\bar{2}\cdot5682-1\cdot5670\end{aligned}$$

from tables; since 138·7 lies between 100 and 1,000, its logarithm has the characteristic 2, and since 0·037 lies between 0·01 and 0·12 its characteristic is $\bar{2}$. It will be found that the characteristic of the logarithm of a number less than one is always numerically one greater than the number of zeros after the decimal point. Proceeding with our evaluation:

$$\begin{aligned}\log_{10}\frac{138\cdot7\times0\cdot037}{36\cdot9} &= +2+0\cdot1422+(-2+0\cdot5682)\\ &\quad -1\cdot567\\ &= 0\cdot7104-1\cdot567\end{aligned}$$

We must always arrange that the mantissa is positive, so we write $0\cdot7104-1\cdot567$ as $1+1\cdot7104-1\cdot567$. Thus we obtain $-1+0\cdot1434$, i.e. $\bar{1}\cdot1434$. This is the logarithm of our original expression, so that we have only to find from our tables the number which has this logarithm to know the evaluation of our expression. The $\bar{1}$ simply tells us that the logarithm is that of a number between 0·1 and 1. To find its actual value we look up the mantissa 1434 in the body of the logarithm table. As accurately as we are able, from our tables, we find that 1433 is the mantissa of 1391, so that our evaluation is 0·1391; this, then, is the value of our original expression.

It should be noticed that the mantissae have also been tabulated called *antilogarithms* to save time. In these tables we look up ·1433 in exactly the same way as for logarithms. Wherever possible a rough check should be made to ensure that the decimal point has been correctly placed; for instance, in our example $\dfrac{138\cdot7\times0\cdot037}{36\cdot9}$ is approximately $\dfrac{138\cdot7}{1000}$ i.e. 0·1387



This instrument enables arithmetical computations to be performed quickly by mechanical means. There are four principal scales: **A** and **D** on the **rule** itself; **B** and **C** on the **slide.** The illustration of a typical slide rule (above) also shows Log-log scales (LU and LL) on top and lower edges respectively. Scales A, B, C, D are, in effect, tables of logarithms plotted out to scale on the rule. A and B are alike.

Multiplication. This and division may be carried out on either upper scales (A and B) or lower scales (C and D). The lower scales enable more accurate working, but the upper ones are generally used where possible. An example is given in Fig. 1. Two numbers are multiplied by **adding** together the distances corresponding to those numbers on rule and slide. Thus, **2·5 × 3 = 7·5**: Set **1** on B under 2·5 on A; move cursor line over 3 on B; read result (7·5) under cursor line on A. The position of slide, etc., is shown in Fig. 1.

Division. Performed by **subtracting** the distance representing the divisor on one of the scales from the distance defining the dividend on the other adjacent scale. Fig. 2 illustrates an example: **7·65 ÷ 4·5 = 1·7.** Set cursor line over 7·65 on D; slide 4·5 on C under the cursor line; read the result 1·7 on D under 1 on C.

Squares and Square Roots. Readings on A are squares of exactly opposite readings on D, so that squares and roots may be read off directly.

Cubes and Cube Roots. A number may be raised to the third power by continued multiplication. See Fig. 3: **$1{\cdot}5^3$ = 3·375.** Set 1 on C to 1·5 on D; move cursor line over 1·5 on B; read result 3·375 under cursor line on A. In finding the **cube root of 27** we should move the cursor line over 27 on A; draw out slide (to the right in this case) until the same number (3) comes under the cursor line on B which registers simultaneously on D under 1 on C.

Illustrations by courtesy of Dargue Bros. Ltd., Halifax

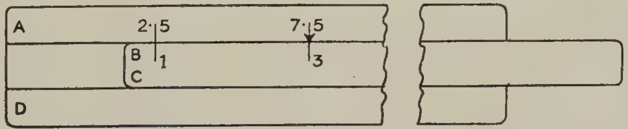


Fig. 1. Multiplication

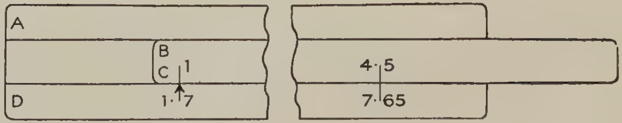
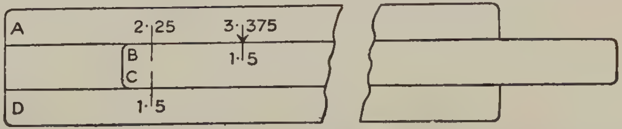


Fig. 2. Division

Fig. 3. Cubing



***PRINCIPLE OF THE SLIDE RULE.** These illustrations, with the accompanying practical description of the use of the slide rule in rapid calculations, are complementary to the text in pages 233-234, where the theory of the rule is discussed. The operations of multiplication, division, and cubing are demonstrated. The scales are, in effect, tables of logarithms plotted to scale. See also Lessons 14 and 15 on Logarithms.*

Example. Find the value of $(0{\cdot}00596)^{1/5}$

$$\log_{10}(0{\cdot}00596)^{1/5} = \frac{1}{5}\log_{10}(0{\cdot}00596)$$

$$= \frac{1}{5}(\bar{3}{\cdot}7752)$$

which means $\frac{1}{5}(-3+0{\cdot}7752)$. Since we must have the mantissa positive, we write this as $\frac{1}{5}(-5+2{\cdot}7752)$, and then on dividing, we obtain $(-1+0{\cdot}5550)$, i.e. $\bar{1}{\cdot}555$.

Thus $\quad \log_{10}(0{\cdot}00596)^{\frac{1}{5}} = \bar{1}{\cdot}555$

so that $\quad (0{\cdot}00596)^{\frac{1}{5}} = \text{antilog } \bar{1}{\cdot}555$

$$= 0{\cdot}3589$$

Notice especially that in the antilogarithm tables, only the 0·555 is looked up, the $\bar{1}$ tells us that the number lies between 0·1 and 1.

Theory of the Slide Rule. This is an instrument which consists of two scales, one of which slides within the other, and its principal purpose is the rapid numerical evaluation of expressions involving multiplications and divisions. A modern slide rule at first sight appears to be an intricate system of graduated scales and numbers which is apt to be confusing, but the theory of the slide rule is very simple—it is only a mechanical device for adding and subtracting the logarithms of numbers.

Suppose we take the numbers from 1 to 10 and find their logarithms to base 10 from a set of tables. We obtain, to three decimal places :

Number	1	2	3	4	5
Logarithm	0	·301	·477	·602	·699
Number	6	7	8	9	10
Logarithm	·778	·845	·903	·954	1

It is very important to notice that although the numbers increase by 1, the logarithms do not increase by constant amounts, but by amounts which are continuously *decreasing*. Thus

$$\log 2-\log 1=0{\cdot}301,$$
$$\log 3-\log 2=0{\cdot}176,$$
$$\log 4-\log 3=0{\cdot}125,$$
$$\log 5-\log 4=0{\cdot}097 \text{ and so on.}$$

Since we are now dealing with common logarithms there is no ambiguity if we drop the suffix 10 to indicate the base. Thus $\log_{10} N$ will be written simply as log N.

From the above set of figures it is an easy matter to construct a scale showing the relative positions of log 1, log 2, log 3, ... to each other (Fig. 87). AJ is taken to represent one unit of length and B, C, D, . . . are placed so that AB=0·301, AC=0·477, AD=0·602, ... If we have two identical scales of this type which will slide one against the other, we have, in effect, a slide rule.

Consider how a pair of such scales may be used (Fig. 88) to multiply two integers together. In this diagram we have depicted the end of one of the scales (C) to be placed opposite to the mark representing log 3 on the other scale (B). Suppose that E is the mark on this scale opposite to log 2 on the first scale. To the logarithm of which number will E correspond ? This is a simple matter using a property of logarithms, for

$$\begin{aligned} AE &= AB+BE \\ &= AB+CD \\ &= \log 3+\log 2 \\ &= \log(3\times 2) \\ &= \log 6 \end{aligned}$$

Thus the reading E represents the point log 6 and alternatively, if the log 6 is read off from the upper scale, then we have automatically multiplied 3 by 2. Equally well we could have divided 6 by 2 by subtracting log 2 from log 6. Thus, if we had placed log 2 on the lower scale against log 6 on the upper scale we should have been able to read off log 3 on the upper scale as the mark opposite to log 1 on the lower.

Now that we know that the scales are logarithmic, it is unnecessary to clutter them up with the words ' log ' in front of each number. If in addition we fill up the spaces between log 1, log 2, log 3 . . . with graduations representing log 1·1, log 1·2, log 1·3, ... and even log 1·11, log 1·12, log 1·13 . . . . we shall have scales from which we can read off multiplications and divisions.

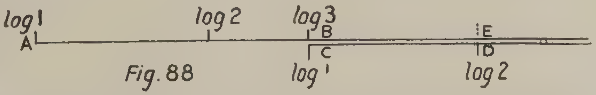


Fig. 88

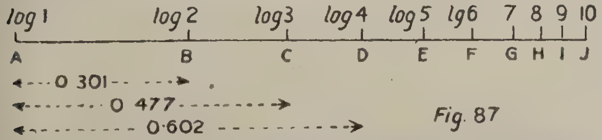
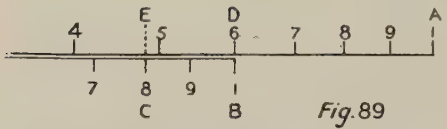


Fig. 87

SLIDE RULE.* *Fig. 87.* *Scale of relative positions of logs 1, 2 onwards.
Fig. 88.* *Pair of adjustable scales to multiply integers by adding logs.

There is, however, one difficulty which the reader may have noticed. If we had, in our previous example, multiplied two numbers together whose product was greater than 10 we should not have been able to obtain the reading at E, as we should have run off the end of the



SLIDE RULE. Fig. 89. Reading logs for a multiplication.

scale. This difficulty is overcome by working from the right-hand end of the lower scale instead of the left-hand end. Suppose we wish to use our slide rule to multiply 6×8 (Fig. 89). (The method will be the same even if the numbers involve decimals.) The end B of the lower scale is placed opposite 6 on the upper scale. The reading E opposite 8 on the lower scale is taken; it will be found to be 4·8. The proof of this is as follows:

$$\begin{aligned} AE &= AD + DE \\ &= AD + BC \\ &= \log 10 - \log 6 + \log 10 - \log 8 \\ &= 2 \log 10 - \log (6 \times 8) \end{aligned}$$

But AE is $\log 10 - \log$ (reading at E)

$$\therefore \quad \log 10 - \log (\text{reading at E}) = 2 \log 10 - \log (6 \times 8)$$

$$\begin{aligned} \therefore \quad \log (\text{reading at E}) &= \log (6 \times 8) - \log 10 \\ &= \log (\tfrac{48}{10}) \\ &= \log 4{\cdot}8 \end{aligned}$$

so that the reading at E is 4·8.

It will be noticed that the onus is on the operator to fix the decimal point—the slide rule gives the numerical value.

As we have stated earlier, a modern slide rule gives a vast amount of information additional to the two scales above; further scales providing sines tangents, squares, and so on. For the use of these and the *cursor* (a sliding piece which enables several multiplications or divisions to be done before the final answer is read off) the student is referred to the explanatory handbook sold with any slide rule.

EXERCISES

Use logarithms to solve the following problems:

(1) Find the product of 432·7 and $\frac{13{\cdot}9}{167{\cdot}5}$

(2) Evaluate $\frac{94 \times 174 \times 5}{176}$

(3) Divide 0·0009197 by 475·25.

(4) Find (i) the cube root of 0·0003,
(ii) $(0{\cdot}03)^{\frac{1}{3}}$,
(iii) $\sqrt[10]{20}$

(5) Find x if $10^x = 3{\cdot}2836$.

(6) If $e = 2{\cdot}718$ find $\log_e 12$.
Find x if $e^x = 11{\cdot}02$.

(7) Find $\log_5 71$

(8) Construct a slide rule by drawing Fig. 87 on as large a scale as possible, extending the short vertical lines to cut AJ, inserting as many intermediate values as possible, duplicating the numbers above and below the line AJ and cutting along AJ with a knife. Use this slide rule to solve the first three questions of this exercise.

Answers to Exercises in Lesson 14

(1) (i) $x^4 - x^{-4}$; (ii) $x^3 + x^2 + x + 1$; (iii) $a^8 - 8b^4$.
(2) (i) 2·25; (ii) 64/81; (iii) 448.
(4) 7.
(5) 1·4330, 2·9389, 2·3715, 0·5623.
(6) $2\frac{1}{3}$, -3, 6.
(8) $a = 9$, $b = 0{\cdot}001$, $c = 2$.
(9) 1·80618.

LESSON 16

Analysing a Problem: Algebraic Identities

We have already covered a considerable amount of ground that has concerned itself with the technique of arithmetic, algebra, geometry and trigonometry. These are tools, like hammers and chisels, that must serve us in the handling of problems.

What is the first step?

Factors in the Problem. Clearly to picture the problem—the shapes and sizes of the things involved. If they are simple geometrical shapes such as circles, lines, triangles and squares then so much the better. This attempt to picture the problem in this way is in effect our method of asking whether the problem can be adequately described in such simple terms.

For example, if we seek where to place four electric lamps in a room to give the most uniform illumination over a table in the centre of the room, consistent with giving sufficient light everywhere for reading, can we represent the lamps as points—points of light? Can we represent the table as a square? Can we draw the room simply as a box consisting of plane faces? What of the reflected light from the walls and the ceiling? Will it matter what size of book is to be read? Will it matter if the reader is ill-tempered? Does he suffer from eye strain? Will it matter if the book is very broad, or if the print is large or small? Or if there are pictures—coloured, or black and white?

A few moments' thought and it will become evident that there is no limit to the possible factors that may enter into the question for that depends on how *deeply* one proposes to study it. The answer to this dilemma is simple. The tools we have at our disposal settle the depth to which we can penetrate and if it turns out that this does not suffice for our purpose, we shall simply have to discover deeper mathematical methods, and mathematical tools better for the purpose.

Geometrical Analysis. Accordingly the first step in our analysis is to ask: What is the geometry of the problem? What shapes are involved and how do they lie with reference to each other?

The next question is: What are the quantities or sizes involved?

Of course, there may be no obvious picture. It may be simply a question of adding sums of money or distances together. So much the easier. Once we have settled the picture and the sizes of the parts we know—we must decide whether we know enough. If we do not know enough we cannot yet solve our problem.

How can we tell whether we have enough data? It is frequently not possible to decide this at once, but where the problem can be represented initially in geometrical form we can decide whether we have enough data by a simple test—can the figure or diagram be drawn from the given data?

For example, suppose we know that of three towns A, B and C, the town A is 40 miles from B and 60 miles from C, while B is 50 miles from C, then by actual drawing on paper we can make a small scale picture of the relative positions of the three towns, with fair accuracy. This first step therefore shows that already there is some justification for thinking of the subject in mere geometrical form and for fixing the picture in this definite way. Suppose it is proposed to erect a factory as nearly as possible at a site at equal distances from the three towns—is this requirement sufficient to settle the location of the factory?

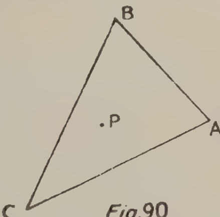


Fig. 90

On our picture (Fig. 90) the problem would have to be expressed in this way:

Is there a point P such that
$PA = PB = PC$?

This requires only to be stated, for us to see that this would mean that we could fix the point of our compass at P, step off PA, and, swinging the compass around P, a circle would be traced out that passed through B and C. Is there such a point P? (*See* Lesson 5.)

Our question asks, in fact—is there a circle that passes through 3 given points? The answer to this we know is—yes. The point P therefore is its centre. To determine the point P, consequently we require the centre of a circle that is to pass through 3 given points. By the time the problem of the location of the factory has been reduced to a statement of this nature we have extracted the mathematical essence from it and can turn our mathematical tools towards its solution.

If we look back on what we have just done we can see that the analysis of a problem proceeds by putting to oneself a series of questions so selected as to bring out the geometrical and numerical features and then so directed as to enable one to decide whether the problem as so stated is a *definite* mathematical problem. By the time this has been achieved it is usually reduced to a form dependent on one of our abstract geometrical propositions. At this stage the ordinary technique comes into operation and all that is thereafter necessary is to reinterpret the mathematical results in terms of the flesh and blood of reality.

Artificial Problems and Reality. There is one final point. What we have been discussing is how to extract the mathematical features from a situation in order to see what information this provides us with concerning that situation. Most books on mathematics in that sense provide artificial problems. They are usually stated in a form already devoid of all but the mathematical features essential for the solution of the problem. Even in the foregoing illustration we have done this; we have given the distances apart of the towns A, B, and C—*along the straight lines joining them* instead of, say, along the roads leading from the one to the other; we have represented the three towns as *points* whereas they are a complicated grouping of streets. houses, shops, schools, churches and human beings; we have assumed that the result we sought did not depend on the weather, the day of the week, the language of the people and a multitude of other factors.

We know from experience, of course, that these have little or nothing to do with the question, with the possible exception of the position of the roads. In assuming that the roads are straight we imply that deviations of existing roads from straightness are of little importance. If those deviations are great, then, of course, the problem would require reconsideration. What the mathematician does is to bring his special additional knowledge and experience to bear in order to set out positively which features in all this medley are of importance for his purpose. In this sense he is only carrying forward a tradition already followed by us all in the circumstances of everyday life.

ALGEBRAIC IDENTITIES

Simplification of Algebraic Expressions. In an earlier Lesson (10) on algebra we have seen that the expression $a-(b-c)$ means $a-b+c$ and we will now consider the simplification of more complicated algebraic expressions. Suppose that the whole of $a-(b-c)$ is to be subtracted from x; then this would be written

$$x - \{a-(b-c)\}$$

Here we have used 'curly' brackets to indicate the whole of the expression $a-(b-c)$. When dealing with more than one bracket it is advisable, in order to minimise the possibility of making an error, to deal with the *innermost* bracket first, thus:

$$\begin{aligned} & x - \{a-(b-c)\} \\ = \ & x - \{a-b+c\} \\ = \ & x - a+b-c \end{aligned}$$

since it will be remembered that a minus (—) sign outside a bracket changes the sign of every term inside. Occasionally it is necessary to have yet a third distinctive type of bracket; thus, for example, if three times the above expression is to be subtracted from 10, say, we write this as

$$10 - 3\,[x-\{a-(b-c)\}]$$

Here we have used 'square' brackets.

Example. Simplify $1-[10a^2-5a\,\{(a+b)-(b-c)\}]$

$$\begin{aligned} \text{This expression } &= 1-[10a^2-5a\,\{a+b-b+c\}] \\ &= 1-[10a^2-5a\,\{a+c\}] \\ &= 1-[10a^2-5a^2-5ac] \\ &= 1-[5a^2-5ac] \\ &= 1-5a^2+5ac \end{aligned}$$

Exactly the same procedure is adopted if powers of several expressions are required. For instance $\{1-(a+b)^2\}^3$ means that a is to be added to b, this sum is to be squared, and subtracted from 1 and the whole resulting expression is to be cubed. We will work through an example which will involve the laws of indices.

Example.

Simplify $x^{-7}[y\{x^{-3}\,(x^2y^2)^{\frac{1}{6}}\}^{-\frac{3}{2}}]^2$

The method of simplification is to commence with the innermost bracket and work outwards. Thus, the expression

$$= x^{-7}[y\{x^{-3}\,x^{\frac{2}{6}}\,y^{\frac{2}{6}}\}^{-\frac{3}{2}}]^2$$

since $(ab)^n = a^n\,b^n$,

$$\begin{aligned} &= x^{-7}[y\{x^{-3}\,x^{\frac{1}{3}}\,y^{\frac{1}{3}}\}^{-\frac{3}{2}}]^2 \\ &= x^{-7}[y\{x^{-3+\frac{1}{3}}\,y^{\frac{1}{3}}\}^{-\frac{3}{2}}]^2 \\ &= x^{-7}[y\{x^{-\frac{8}{3}}\,y^{\frac{1}{3}}\}^{-\frac{3}{2}}]^2 \\ &= x^{-7}[y\,x^{(-\frac{8}{3})\,(-\frac{3}{2})}\,y^{\frac{1}{3}(-\frac{3}{2})}]^2 \end{aligned}$$

Notice particularly at this stage that the y is not raised to the power $-\frac{3}{2}$, only the quantity inside the 'curly' bracket. Continuing,

$$\begin{aligned} \text{the expression } &= x^{-7}[yx^{\frac{24}{6}}\,y^{-\frac{3}{6}}]^2 \\ &= x^{-7}[y^{1-\frac{1}{2}}\,x^4]^2 \\ &= x^{-7}[y^{\frac{1}{2}}\,x^4]^2 \\ &= x^{-7}\,y^{2(\frac{1}{2})}\,x^8 \\ &= x^{8-7}\,y \\ &= xy \end{aligned}$$

Algebraic Factors. When we were considering the multiplication of algebraic expressions we found that

$$(x-y)\,(x+y) = x^2 - y^2.$$

If we commence with the expression x^2-y^2 and split it up into $x-y$ multiplied by $x+y$ we are factorizing x^2-y^2 in exactly the same way as we factorized numbers in arithmetic. It should be noticed that when we write

$$x^2 - y^2 = (x-y)\,(x+y\,). \;.\;.\;.\;.\;.\;.\;. \quad (i)$$

we are stating an algebraic identity, i.e. this relation is true for all values of x and y. Thus:

$$\begin{aligned} 12^2-5^2 &= (12-5)\,(12+5), \\ 6^2-5^2 &= (6-5)\,(\,6+5), \\ 256^2-255^2 &= (256-255)\,(256+255). \end{aligned}$$

The reader should verify these arithmetical examples. This process can be extended; thus:

$$\begin{aligned} &(4z)^2-7^2 = (4z-7)\,(4z+7), \\ &x^2-(y+z)^2 = \{x-(y+z)\}\,\{x+(y+z)\} \end{aligned}$$

Obviously, relation (i) is very important: it is known as the '*difference of two squares.*' By its aid we may factorize other expressions involving higher powers of x and y. Consider x^4-y^4. This is $(x^2)^2-(y^2)^2$ and so we write

$$\begin{aligned} x^4-y^4 &= (x^2)^2-(y^2)^2 \\ &= (x^2-y^2)\,(x^2+y^2) \\ &= (x-y)(x+y)\,(x^2+y^2), \end{aligned}$$

and here we have been enabled to find the three factors of x^4-y^4. Notice that x^2+y^2 will not factorize in this way.

The difference and the sum of two cubes are two other fundamental forms which factorize; the results are:

$$x^3-y^3 = (x-y)\,(x^2+xy+y^2) \;.\;.\;. \quad (ii)$$

and $$x^3+y^3 = (x+y)\,(x^2-xy+y^2) \;.\;. \quad (iii)$$

These are important and should be memorized; they may be verified in each case by multiplying out the right-hand side (R.H.S.). It is also a good plan to check by arithmetical examples. For instance:

$$7^3-3^3=(7-3)\,(7^2+7\times3+3^2)$$

i.e. $343-27=4\,(49+21+9)$

$$=4\,(79)$$

$$=316 \qquad \text{which is true.}$$

The reader should verify that

$$5^3+4^3=(5+4)\,(5^2-5\times4+4^2)$$

and $17^3-1^3=(17-1)\,(17^2+17\times1+1^2)$.

Many algebraic expressions may be factorized by comparing them with one of the fundamental forms (i), (ii) or (iii). Some examples are:

(1) $a^3+8b^3=a^3+(2b)^3$

$$=(a+2b)\,\{a^2-a(2b)+(2b)^2\}$$

$$=(a+2b)\,(a^2-2ab+4b^2),$$

(2) $x^6-y^6=(x^2)^3-(y^2)^3$

$$=(x^2-y^2)\,\{(x^2)^2+x^2y^2+(y^2)^2\}$$

$$=(x^2-y^2)\,(x^4+x^2y^2+y^4)$$

$$=(x-y)\,(x+y)\,(x^4+x^2y^2+y^4)$$

(3) $(x+y)^3+z^3=\{(x+y)+z\}\{(x+y)^2-(x+y)z+z^2\}$

In this example we have simply taken relation (iii) and replaced x by $x+y$ and y by z.

Another method of factorizing algebraic expressions is by the grouping of terms together. Consider an example. Suppose we wish to find the factors of $3+7x-3x^2-7x^3$. We may rewrite the expression

$$=3-3x^2+7x-7x^3$$

$$=3(1-x^2)+7x(1-x^2)$$

Now $1-x^2$ divides into each term, i.e., the above expression must have been obtained by multiplying out $(3+7x)\,(1-x^2)$ so that these are the factors. Since $1-x^2$ is itself the difference of two squares, the expression factorizes one stage further into $(3+7x)\,(1-x)\,(1+x)$.

Quadratic Expressions. We will deal now with a very important form. Suppose we multiply $x+2$ by $x+3$ we find—

$$(x+2)\,(x+3)=x(x+3)+2(x+3)$$

$$=x^2+3x+2x+6$$

$$=x^2+5x+6.$$

The expression on the R.H.S. is called a *quadratic* expression because it involves a term in x^2 and no terms of higher powers. An algebraic problem of frequent practical occurrence is to split up quadratic expressions into their factors. We shall obtain help in this direction by multiplying $x+a$ by $x+b$. We obtain

$$(x+a)\,(x+b)=x(x+b)+a(x+b)$$

$$=x^2+bx+ax+ab$$

$$=x^2+(a+b)x+ab$$

and we can now see the connexion between the numbers a and b in the factors, and in the terms on the R.H.S. It will be noticed that the coefficient of x on the R.H.S. is the sum of a and b, while the third term is their product. This means, for example, that if we wish to factorize $x^2+9x+20$ we must find two numbers which when added together give 9 and when multiplied together give 20. By trial and error it will quickly be found that the numbers are 4 and 5, thus

$$x^2+9x+20=x^2+(4+5)x+4\times5$$

$$=(x+4)\,(x+5)$$

Other important forms are

$$(x+a)\,(x-b)=x^2+(a-b)x-ab$$

and $(x-a)\,(x-b)=x^2-(a+b)x+ab$

Example. Factorize x^2-2x-3.

Since this is of the form $(x+a)\,(x-b)$, (which it must be because the last term is -3), we require $ab=-3$ so that either $a=1$, $b=-3$ or $a=-1$, $b=3$, i.e., the factors are either $(x+1)\,(x-3)$ or $(x-1)\,(x+3)$. The first of these on multiplication gives x^2-2x-3 whereas the second gives x^2+2x-3.

Thus $x^2-2x-3=(x+1)\,(x-3)$.

We shall return to a study of quadratic expressions in the Lesson on algebraic equations (pages 239–243).

Algebraic Identities. We have already stated that when we write $x^2-y^2=(x-y)\,(x+y)$ we are stating an algebraic identity, but it must be realized that an identity need not be in the form of factors. Whenever we have two algebraic expressions which are equal for all values of x, but are in different forms, we have an identity. As an example consider

$$3x=2(x-1)+x+2.$$

The R.H.S. when simplified reduces exactly to $3x$, quite independently of any value of x. That this statement is true can be shown by substituting *any* value for x and verifying that the numerical value of both sides is equal. We may consider here a general problem in identities which is of practical importance. Suppose we had been asked to find the values of the constants A and B in order that

$$3x=A(x-1)+B(x+2)$$

shall be an identity. We can see by comparing this relation with the one above that $A=2$, $B=1$, but the problem is to find these values without any previous knowledge. We proceed in the following way. Since—

$$3x=A(x-1)+B(x+2)$$

is to be an identity it is to be true for *all* values of x, this means that we may give whatever values we please to x and the relation will still be true. This fact provides us with the necessary information to determine A and B. Notice that if we choose $x=1$ as one value, the first term of the R.H.S. equals A × 0, i.e. zero, so that we shall find B immediately. Thus when $x=1$

$$3=0+B(1+2)$$
i.e. $3B=3$
so that $B=1$.

Similarly, by putting $x=-2$ the second term on the R.H.S. becomes zero and we find A directly. If $x=-2$.

$$3(-2)=A(-2-1)+0$$
i.e. $-6=-3A$
or $A=2$.

By using this method wherever possible, a great deal of labour is saved in determining the constants. We give another example.

Example. If $x^2+9=A(x+1)(x+2)+B(x+2)(x+3)+C(x+3)(x+1)$ find A, B and C.

As in the last example, we choose values of x which make some of the brackets on the R.H.S. become zero, namely $x=-1$, $x=-2$, $x=-3$.

If $x=-1$
$$1+9=A.0.1+B.1.2+C.0.2$$
i.e. $10=2B$
so that $B=5$
If $x=-2$
$$4+9=A.-1.0+B.0.1+C.-1.1$$
i.e. $13=-C$
or $C=-13$
Lastly, if $x=-3$
$$9+9=A.-2.-1+B.-1.0+C.-2.0$$
i.e. $18=2A$
or $A=9$
Thus:

$$x^2+9=9(x+1)(x+2)+5(x+2)(x+3)-13(x+1)(x+3).$$

The reader should multiply out the R.H.S. and verify that it simplifies to x^2+9.

Functions. We have stated in an earlier Lesson (11) that an expression which depends for its value on x is called a *function* of x, usually denoted by $f(x)$ or $F(x)$. We may conveniently use this notation to indicate the value of the function for a particular value of x. Consider an example—

If $f(x)=x^3-2x+1$

then $f(3)$ means the value of this function (in this case a *cubic* function) when $x=3$,

i.e. $f(3)=3^3-2.3+1$
$=27-6+1$
$=22$
Again $f(1)=1-2.1+1$
$=0$
and $f(0)=0-0+1$
$=1$
and $f(x+a)=(x+a)^3-2(x+a)+1$.

We simply replace x by a particular value or quantity throughout the whole expression.

Any series of terms which involve the sum of integral powers of x together with constants is termed a *polynomial* function of x. We may write such a function quite generally as

$$f(x)=a_0x^n+a_1x^{n-1}+a_2x^{n-2}+\ldots a_{n-1}x+a_n$$

where a_0, a_1, . . . a_n are constant *coefficients* (some may be zero) and n denotes the *degree* of the function. Thus a function such as x^2-3x+7 is a *quadratic* function because in this case $n=2$. It is said to be of the *second* degree. Again x^7+x-3 is of the seventh degree because 7 is the highest power in this function. A function of the first degree, for example $3x-4$, is said to be *linear*.

The Remainder Theorem. This theorem states that if a polynomial function of x, $f(x)$, is divided by $x-a$, then the remainder is $f(a)$. Before we prove this theorem we will consider what it means in terms of an actual example. Consider a function of x given by

$f(x)=x^3+5x^2-7x+15$ and suppose that this is divided by $x-2$.

The theorem states that the remainder is $f(2)$. Now

$$f(2)=2^3+5.2^2-7.2+15$$
$$=29$$

so that this is the remainder on dividing $f(x)$ by $x-2$. This may easily be verified by long division; it will be found that

$$\frac{x^3+5x^2-7x+15}{x-2}=x^2+7x+7+\frac{29}{x-2}$$

i.e. the remainder is 29.

Notice that the R.H.S. of this expression could be written

$$\frac{(x^2+7x+7)(x-2)+29}{x-2}$$

We may now proceed with the proof of the remainder theorem: if $f(x)$ denotes any polynomial function of x, when this function is divided by $x-a$, the quotient will be another function of x and the division may be continued until only a numerical remainder is left. Thus we may write

$$\frac{f(x)}{x-a}=F(x)+\frac{R}{x-a}\quad\ldots\ldots\ldots\quad (i)$$

where $F(x)$ denotes the quotient and R denotes the numerical remainder. For instance, in our example, $F(x)=x^2+7x+7$, $R=29$. We may rewrite relation (i) as

$$\frac{f(x)}{x=a}=\frac{(x-a)\,F(x)+R}{x-a} \quad \ldots\ldots \quad (ii)$$

simply by putting the R.H.S. over the common denominator $x-a$ exactly as we did in our example above. Since in (ii) the denominators of both sides are the same, we have

$$f(x) = (x-a)\ F(x) + R.$$

This is an identity and therefore we may put $x=a$. Thus

$$\begin{aligned} f(a) &= 0 \times F(a) + R \\ &= R \end{aligned}$$

so that the numerical remainder equals $f(a)$.

This theorem is of great help in finding the factors of an expression, for if it should happen that $f(a)=0$ then $R=0$, i.e. that there is no remainder when $f(x)$ is divided by $x-a$. Now if there is no remainder when $f(x)$ is divided by $x-a$ the latter is a factor of $f(x)$. Consider an example.

Example. Show that $x-1$, $x-2$, $x-3$ are all factors of $x^3-6x^2+11x-6$.

If $f(x) = x^3-6x^2+11x-6$, then we have only to show that $f(1)$, $f(2)$, $f(3)$ are all zero to prove that $x-1$, $x-2$, $x-3$ are factors.

$$\begin{aligned} f(1) &= 1^3-6.1^2+11.1-6 \\ &= 1-6+11-6 \\ &= 0\ , \\ f(2) &= 2^3-6.2^2+11.2-6 \\ &= 8-24+22-6 \\ &= 0\ , \\ \text{and}\quad f(3) &= 3^3-6.3^2+11.3-6 \\ &= 27-54+33-6 \\ &= 0 \end{aligned}$$

i.e. $x-1$, $x-2$, $x-3$ are all factors of $x^3-6x^2+11x-6$.

Example. Find a so that $x^3+ax^2+(a+10)\,x+15$ may be divisible by $x+3$.

If $f(x) = x^3+ax^2+(a+10)x+15$, then there is to be no remainder when $f(x)$ is divided by $x+3$, i.e. $f(-3)$ must equal zero.

$$\begin{aligned} f(-3) &= (-3)^3+a(-3)^2+(a+10)(-3)+15 \\ &= -27+9a-3(a+10)+15 \\ &= 6a-42\ ; \end{aligned}$$

$$\begin{aligned} &\text{i.e if } f(-3) = 0 \\ &\text{then}\quad 6a-42 = 0 \\ &\text{i.e.}\quad 6a = 42 \\ &\qquad a = 7 \end{aligned}$$

so that if $a=7$, $f(x)$ is divisible by $x+3$, i.e. $x^3+7x^2+17x+15$ is divisible by $x+3$.

EXERCISES

(1) Simplify

(i) $(x+x^{-1})^2-(x^2+x^{-2})$

(ii) $\dfrac{(2^{x+2})^y}{2^{x(y+2)}} \times \dfrac{2^{3x}}{2^{3y}} \times 2^y$

(iii) $\left\{\left(2+\frac{1}{x}\right)^5 \left(2-\frac{1}{x}\right)^2\right\} \div \left\{\left(x+\frac{1}{2}\right)^5 \left(x-\frac{1}{2}\right)^2\right\}$

(2) Show that

$$\left(\frac{x}{y}-\frac{y}{x}\right)\left(\frac{x+y}{x-y}-\frac{x-y}{x+y}\right)=4$$

(3) Factorize
(i) a^3+8b^3,
(ii) x^3+27y^6,
(iii) $(a+b)^2-(c+d)^2$,
(iv) $x^2+2zx-y^2-2zy$,
(v) $\sin^3 A+\cos^3 A$.
(vi) $x^2+8x+15$, (vii) x^2-x-6,
(viii) $x^2-7x+12$.

(4) Use the remainder theorem to find the remainder when x^3-8x^2+7 is divided by $x-2$, and check by long division.

(5) Show that $x+1$, $x-3$, $x-4$ are factors of $x^3-6x^2+5x+12$.

(6) If $f(x)$ is divided by $mx-a$ show that the remainder is $f\left(\frac{a}{m}\right)$. Hence show that $2x-3$ is a factor of $6x^3-9x^2-8x+12$.

(7) If $f(x)=x^3-4x^2+8$, find $f(0)$, $f(1)$, $f(2)$, and hence find a factor of $f(x)$.

(8) If $3x+7=A(x+1)+B(x+2)$, find A and B.

(9) Find A, B and C if $13+4x-x^2=A(x^2-1)+B(x+1)(x-3)+C(x-3)(x-1)$.

(10) Factorize (i) x^3+3x^2-x-3,
(ii) x^3-1,
(iii) x^3+7x^2-36.

Answers to Exercises in Lesson 15

(1) 35·905. (2) 464·63.
(3) 0·000, 001, 935,2.
(4) (i) 0·066942. (ii) 0·31075. (iii) 1·3493
(5) 0·51635. (6) 2·4849, 2·40. (7) 2·64856

LESSON 17

Simple Algebraic Equations

In earlier Lessons we have considered identities, both algebraic and trigonometrical, and have emphasized the essential difference between identities and equations. Now we will turn our attention to the study of *algebraic equations*, which are equivalent relations, true only for particular values of the letters involved. For instance

$$x^2=9;\ 3+x=6;\ x+y=8\ ;\ x^3+1=0$$

are all algebraic equations and we will attempt to *solve* these equations. *Solving* an equation means finding the value or values of the unknown quantity for which the equation is true. Thus, $x^2=9$ has two *solutions*, because if x is either $+3$ or -3 the equation is true. On the other hand $3+x=6$ has only one solution; by subtracting 3 from both sides, we see that $x=3$.

Now examine the equation $x+y=8$: it is obvious that any number of different solutions may be found; for instance

$$x=1,\ y=7$$

satisfies the equation, so also does

$$x=16,\ y=-8\,;$$

and again $x=2\frac{1}{2}$, $y=5\frac{1}{2}$.

There is no end to the number of solutions obtainable. Notice that this fact does not make it an identity; although $x+y=8$ has an infinite number of solutions, it is obviously *not* true for *all* values of x and y.

The last example we gave, namely $x^3+1=0$ can be solved by subtracting 1 from both sides so that $x^3=-1$, and by taking the cube root of both sides we obtain $x=-1$ apparently as the only distinct solution. It is clear that if we are to study equations we shall have to do so systematically, and we commence with the simplest type.

Linear Equations. This is the name given to equations in which there are no letters raised to a higher power than the first and the name is derived from the fact, as we shall see in Lesson 20, that this type of equation is associated with a straight line in the study of algebraic geometry. The solution of a linear equation with one unknown can always be found by simplifying the algebra until the value of the unknown letter is obtained.

Example. Solve the equation—

$$\tfrac{1}{2}(x-2)-4(x-3) = 4$$

Simplifying the L.H.S. we obtain

$$\tfrac{1}{2}x-1-4x+12 = 4$$

i.e. $-3\frac{1}{2}x = -7$

or $7x = 14$ by multiplying both sides by -2.

i.e. $x = 2.$

We found in an earlier example that an equation with two unknowns could have an infinite number of solutions, and consequently if we have two unknowns, we require two equations to be true at the same time in order to fix the values of the two unknowns exactly. A pair of such equations is called a pair of *simultaneous equations*.

Consider the following problem: John and Harold have together the sum of £5. How much has each? Obviously we cannot answer this question without further information: if x is the amount of John's money, y the amount of Harold's, then we only have the single equation

$$x + y = 5 \qquad (i)$$

But if we are told at the same time that John has four times as much as Harold, then we are given a second equation namely

$$x = 4y \qquad (ii)$$

This additional information now fixes the amount of money each has because we may replace the x in (i) by $4y$ since equation (ii) states that $x=4y$. Thus (i) becomes

$$4y + y = 5$$

i.e. $5y = 5$

or $y = 1$

so that Harold has £1 and consequently John has £4.

Notice particularly the method of solution: between the two equations we have *eliminated* x, i.e. we have found a linear equation involving y only and this we solved to find the value of y.

We may generalize this method of solving simultaneous linear equations: Suppose we have

$$ax+by=m \qquad (iii)$$

and

$$cx+dy=n \qquad (iv)$$

where a, b, c, d, m, n are constants, then to solve these we require to eliminate either x or y. This may most easily be done by multiplying (iii) by the coefficient of y in (iv), and (iv) by the coefficient of y in (iii) and subtracting, thus:

(iii) multiplied by d gives

$$adx+bdy=md \qquad (v)$$

and (iv) multiplied by b is

$$bcx+bdy=nb \qquad (vi)$$

Notice that now we have exactly the same term in y in both equations, therefore subtracting (vi) from (v) we obtain an equation in x only, thus:

$$adx-bcx = md-nb$$

i.e. $x(ad-bc) = md-nb$

or $$x = \frac{md-nb}{ad-bc}$$

Here we have found the value of x in terms of our constants and by substituting this value of x in either (iii) or (iv) we obtain the value of y.

Quadratic Equations. In the last Lesson we defined a quadratic function or expression and if we have a quadratic expression equal to zero, we have what is termed a quadratic equation. These equations are of very common occurrence in practical work and consequently are important. The example we considered earlier in this Lesson, namely $x^2=9$, is an example of the simplest type of quadratic equation. Notice that there are *two* solutions and they can be written down on sight by taking the square root of both sides. We see that if $x=+3$ or -3 the equation is satisfied. If a quadratic equation factorizes, its solution is simply obtained; indeed we may solve our example above by this method, for if

$$x^2=9$$

then $$x^2-9=0.$$

The L.H.S. is the difference of two squares so that we may write

$$(x-3)(x+3)=0.$$

If we have a product, such as this, equal to zero then either $x-3=0$ or $x+3=0$. If $x-3=0$, then $x=+3$, and alternatively if $x+3=0$, then $x=-3$ so that we have the same values for x as before.

Consider another example of a quadratic equation soluble by factorizing.

Example. Solve the quadratic equation

$$x^2+14x-32=0.$$

To factorize the L.H.S. we require two numbers such that their product is -32 and their sum 14. By trial and error we find these numbers to be 16 and -2, so that we may write the equation

$$(x+16)(x-2)=0.$$

Thus either $x+16=0$ or $x-2=0$

i.e. $x=-16$ or $x=2$.

We require at this stage to notice a method of solving quadratic equations which does not depend on factorization. It is generally known as 'solving by completing the square' and is carried through as follows—

Consider the example solved above: we may write it

$$x^2+14x=32$$

Now the L.H.S. of this expression may be made a perfect square by the addition of a number equal to the square of half the coefficient of x. In this case the coefficient of x is 14, so that half this coefficient is 7. By adding 7^2, i.e. 49 to the L.H.S. we make the L.H.S. exactly $(x+7)^2$. In order not to alter the truth of our equation we must add this same quantity to the R.H.S. Thus the equation becomes

$$x^2+14x+49=32+49$$

i.e. $$(x+7)^2=81.$$

Taking the square root of both sides we obtain

$$x+7=\pm 9$$

i.e. $x+7=+9$ or $x+7=-9$

i.e. $x=+2$ or $x=-16$

which agree with the values obtained by factorization. The value of this method is that it can be applied to cases which cannot be factorized.

Example. Solve $x^2+6x+7=0$.

This may be written

$$x^2+6x=-7.$$

The L.H.S. will become $(x+3)^2$ if we add the square of half the coefficient of x namely, 3^2 i.e. 9, so that

$$x^2+6x+9=9-7$$

or $$(x+3)^2=2.$$

On taking the square root of both sides we obtain

$$x+3=+\sqrt{2} \text{ or } x+3=-\sqrt{2}$$

i.e. $x=-3+\sqrt{2}$ or $x=-3-\sqrt{2}$.

Taking $\sqrt{2}$ as 1·414 these values become

$$x=-1{\cdot}586 \text{ or } x=-4{\cdot}414.$$

At this stage a difficulty may arise if before we take the square root, the number on the R.H.S. is negative. Consider the equation $x^2+9=0$. To solve this we would write

$$x^2=-9$$

but we cannot take the square root because no number can be found such that when it is squared the result is -9. Every number squared is positive, so that when the square of the unknown is negative, it is said that no *real* solutions of the equation exist. For further mathematical work it is useful to introduce the conception of an *imaginary* number so that the solutions of the above would be written $+\sqrt{-9}$ and $-\sqrt{-9}$. It must be clearly understood that these are not *real* values in the usual sense.

The method of solution of a quadratic equation by 'completing the square' is so important that we will consider the general case.

Every quadratic equation may be written in the form

$$ax^2+bx+c=0 \qquad (vii)$$

where a, b, c are constants. (Either b or c may in some cases be zero, but this will not affect our argument. If a were zero, the equation would no longer be quadratic.)

If we divide (vii) all the way through by a, we obtain

$$x^2+\frac{b}{a}x+\frac{c}{a}=0$$

and keeping only the terms involving x on the L.H.S. this becomes

$$x^2+\frac{b}{a}x=-\frac{c}{a}.$$

To make the L.H.S. a perfect square we require to add to it $\left(\frac{1}{2}\cdot\frac{b}{a}\right)^2$, and in order not to destroy the relationship of equality, we must add this same amount to the R.H.S. as well. Thus:

$$x^2 + \frac{b}{a}x + \left(\frac{b}{2a}\right)^2 = \left(\frac{b}{2a}\right)^2 - \frac{c}{a}.$$

The L.H.S. is now

$$\left(x + \frac{b}{2a}\right)^2 \text{ so that}$$

$$\left(x + \frac{b}{2a}\right)^2 = \frac{b^2}{4a^2} - \frac{c}{a} = \frac{b^2-4ac}{4a^2}.$$

Taking the square root of both sides

$$x+\frac{b}{2a} = \pm\sqrt{\frac{b^2-4ac}{4a^2}}$$

$$= \pm\frac{1}{2a}\sqrt{(b^2-4ac}$$

so that either

$$x + \frac{b}{2a} = \frac{1}{2a}\sqrt{(b^2-4ac)}$$

or $$x + \frac{b}{2a} = -\frac{1}{2a}\sqrt{(b^2-4ac)}$$

Thus:

$$x = -\frac{b}{2a} + \frac{1}{2a}\sqrt{(b^2-4ac)}$$

or $$x = -\frac{b}{2a} - \frac{1}{2a}\sqrt{(b^2-4ac)}$$

This may be put in a slightly simpler form by putting the R.H.S. over a common denominator $2a$ in both cases, i.e.

$$x = \frac{-b + \sqrt{(b^2-4ac)}}{2a}$$

or $$x = \frac{-b - \sqrt{(b^2-4ac)}}{2a}$$

These two solutions may be combined in the single formula

$$x = \frac{-b \pm \sqrt{(b^2-4ac)}}{2a} \quad \ldots \quad (viii)$$

and the importance of this lies in the fact that it enables us to write down the solutions of any quadratic equation by substituting the values of a, b and c. To revert to our previous example $x^2+14x-32=0$, we see that $a=1$, $b=14$, $c=-32$, so that the two solutions are given by

$$x = \frac{-14 \pm \sqrt{(14^2 + 4\cdot 1.32)}}{2}$$

$$= \frac{-14 \pm \sqrt{(196 + 128)}}{2}$$

$$= \frac{-14 \pm 18}{2}$$

$$= -7 \pm 9$$

$$= +2 \text{ or } -16.$$

The formula (viii) should be remembered. It is clear that if the solutions of any quadratic are to be real, this requires that the quantity under the square root sign is positive, i.e. b^2-4ac must be positive, i.e. $b^2 > 4ac$. If, on the other hand, $b^2 < 4ac$ the quantity b^2-4ac will be negative and we shall have imaginary solutions. If $b^2=4ac$, there is no plus or minus quantity so that the two solutions are real and equal.

The values of x which satisfy an equation are known as the *roots* of the equation and are often denoted by the Greek letters α (alpha) and β (beta). Thus we may take

$$\alpha = \frac{-b+\sqrt{(b^2-4ac)}}{2a} \quad \text{and}$$

$$\beta = \frac{-b-\sqrt{(b^2-4ac)}}{2a} \quad \ldots\ldots\ldots \quad (ix)$$

Relations between Roots and Coefficients of a Quadratic Equation. These relations may be obtained very simply from (ix), thus:

$$\alpha+\beta = \frac{-b}{2a} + \frac{\sqrt{(b^2-4ac)}}{2a} - \frac{b}{2a} - \frac{\sqrt{(b^2-4ac)}}{2a}$$

$$= \frac{-2b}{2a}$$

$$= \frac{-b}{a} \quad \ldots\ldots\ldots\ldots\ldots \quad (x)$$

Again

$$\alpha\beta = \left(\frac{-b}{2a} + \frac{\sqrt{(b^2-4ac)}}{2a}\right)\left(\frac{-b}{2a} - \frac{\sqrt{(b^2-4ac)}}{2a}\right)$$

and the R.H.S. of this is of the form

$$(x+y)\,(x-y) \text{ where } x = \frac{-b}{2a}$$

and $$y = \frac{\sqrt{(b^2-4ac)}}{2a}$$

We know that

$$(x+y)\,(x-y) = x^2 - y^2,$$

so that

$$\alpha\beta = \left(\frac{-b}{2a}\right)^2 - \left(\frac{\sqrt{(b^2-4ac)}}{2a}\right)^2$$

$$= \frac{b^2}{4a^2} - \frac{(b^2-4ac)}{4a^2}$$

$$= \frac{b^2-b^2+4ac}{4a^2}$$

$$= \frac{c}{a} \quad \ldots\ldots\ldots\ldots\ldots \quad (xi)$$

These results should be remembered: (1) that the sum of the roots of a quadratic equation is equal to the coefficient of x divided by the coefficient of x^2, with the sign changed; and (2) the product of the roots is the independent term divided by the coefficient of x^2.

Example. Solve the equation

$$(x-3)(x+6) = (a-3)(a+6)$$

where a is some constant.

From the form of this quadratic equation we see *by inspection* that $x=a$ is one solution because when x is put equal to a, the equation is obviously satisfied. Thus a is one root. By considering the L.H.S. alone we see that on multiplication it becomes $x^2+3x-18$, i.e. the coefficient of x^2 is 1 and the coefficient of x is 3. Thus, the sum of the roots is -3, but one root is a; therefore, the other root is $-3-a$. Our two solutions are therefore $x=a$ and $x=-3-a$.

Equations of Any Degree. There are no simple general methods for solving equations of a higher degree than a quadratic and where such solutions are required it is necessary to obtain first approximate solutions and then to refine these approximations. We shall consider this problem in Lesson 19. There are, however, some particular methods; for instance an equation such as $ax^4+bx^2+c=0$ may be solved as a quadratic in x^2. Again the remainder theorem (p. 238) may be useful. Any equation of the nth degree in x may be written $f(x)=0$ and so if a value of x can be found, say α, such that $f(\alpha)=0$, then α must be a root of the equation because if $f(\alpha)=0$, this means that $f(x)$ is divisible by $x-\alpha$, i.e. $x-\alpha$ is a factor of $f(x)$ i.e. $x=\alpha$ is one of the solutions of $f(x)=0$.

Example. Solve the equation

$$x^3 + 9x^2 + 6x - 56 = 0 \quad \ldots . \quad (xii)$$

Put $f(x) = x^3 + 9x^2 + 6x - 56$ and find $f(1)$, $f(2)$, $f(3)$, . . . $f(-1)$, $f(-2)$ . . . and so on. Thus:

$$\begin{aligned} f(1) &= 1 + 9 + 6 - 56 = -40 \\ f(2) &= 2^3 + 9.2^2 + 6{\cdot}2 - 56 \\ &= 8 + 36 + 12 - 56 \\ &= 0 \end{aligned}$$

so that $f(x)$ is divisible by $x-2$. Therefore one of the roots of $f(x)=0$ is $x=2$ and by long division of $\dfrac{f(x)}{x-2}$ we will obtain a quadratic expression which will provide two more roots.

By long division $x^3+9x^2+6x-56$ divided by $x-2$ equals $x^2+11x+28$ so that we may write (xii) as

$$(x-2)(x^2+11x+28) = 0$$

The quadratic term factorizes so that this becomes

$$(x-2)(x+7)(x+4) = 0$$

Thus there are three roots and their values are 2, -7 and -4.

EXERCISES

(1) Solve the equations:

(i) $3(x-3)=7(x-7)$,
(ii) $3(x+1)^2+(x-1)^2=4x^2$,
(iii) $(x+1)(x+2)-(x-1)(x-2)=9$.

(2) Solve the simultaneous equations:

(i) $x-y=8$, $x+y=4$,
(ii) $2x+3y=13$, $5x-7y=18$,
(iii) $\frac{1}{2}(x+1)+\frac{1}{3}(y+1)=6$, $x+y=13$.

(3) Solve the following equations by factorization:

(i) $x^2-3x-28=0$,
(ii) $x^2+x-72=0$,
(iii) $x^2+12x=0$,
(iv) $x^2+9=6x$,
(v) $x^3+6x^2+5x=0$,
(vi) $3x^2-8x-3=0$.

(4) By 'completing the square,' solve the equations:

(i) $x^2-9x+17$,
(ii) $\frac{1}{3}x^2-\frac{1}{2}x=9$,
(iii) $2x^2+5x+8=0$.

(5) By means of the rule for writing down the roots of a quadratic equation, check the solutions obtained for the equations in questions (3) and (4).

(6) Find the sum and product of the roots of the following equations without solving them:

(i) $3x^2+7x+11=0$,
(ii) $x^2+x-10=0$,
(iii) $x(x+1)+(x+1)(x+2)=2$.

In which of these equations are the roots real and which imaginary?

(7) Solve the equation $x^4-13x^2+36=0$.

(8) Use the remainder theorem to show that the equation $x^3-2x^2-x-6=0$ has one real and two imaginary roots and find them.

(9) Solve the equation $x^3-5x^2+2x+8=0$.

Answers to Exercises in Lesson 16

(1) (i) 2, (ii) 2^x, (iii) $128x^{-7}$.
(3) (i) $(a+2b)\ a^2-2ab+4b^2)$.
(ii) $(x+3y^2)(x^2-3xy^2+9y^4)$.
(iii) $(a+b+c+d)(a+b-c-d)$.
(iv) $(x-y)(x+y+2z)$.
(v) $(\sin A+\cos A)(\sin^2 A-\sin A\cos A + \cos^2 A)$.
(vi) $(x+3)(x+5)$.
(vii) $(x-3)(x+2)$.
(viii) $(x-3)(x-4)$.
(4) -17.
(7) $f(0)=8$, $f(1)=5$, $f(2)=0$, $x-2$.
(8) $A=-1$, $B=4$.
(9) $A=2$, $B=-4$, $C=1$.
(10) (i) $(x-1)(x+1)(x+3)$
(ii) $(x-1)(x^2+x+1)$
(iii) $(x-2)(x+3)(x+6)$.

LESSON 18

Trigonometrical Equations

Having studied algebraic equations in the last Lesson, we will devote this one to the study of trigonometrical equations since there are many points of similarity between the two.

Consider a very simple example such as sin $A=\frac{1}{2}$, and let us examine what will be meant by the *solution* of this equation. Since sin 30° is $\frac{1}{2}$ it is clear that $A=30°$ is one value of A which satisfies our equation. This value is a *root* in exactly the same sense as we had a root of an algebraic equation. It is clear also that there will be a large number of additional roots for there is an angle in the second quadrant, i.e. between 90° and 180° for which the sine is $\frac{1}{2}$ and again any multiple of 360° can be added to either of the two solutions already indicated to give further roots.

To find all these values exactly, the procedure is as follows: draw a diagram as in Fig. 91, and find the solution in the first quadrant (in this case 30°). Since we are dealing with a sine in this example, and since any sine is positive also in the second quadrant we have the solution $180°-30°$, i.e., 150°. In the third and fourth quadrants the sine is negative so that there can be no solutions of our equation in these quadrants but the angle $360°+30°$ gives an angle in the first quadrant again, still with the sine equal to $\frac{1}{2}$, so that the general formula $n.360°+30°$ will account for all solutions in the first quadrant by putting n equal to 0, 1, 2, ... successively.

The general formula $n.360°+150°$ will similarly give all solutions lying in the third quadrant. It should be noticed that these two sets of solutions may be combined into the one general formula:

$$A=m.180°+(-1)^m\,30° \quad . \quad . \quad . \quad . \quad . \quad (i)$$

by successively putting $m=0, 1, 2, 3, . \;. \;.$

Thus, if $m=0$, $A=\;+30°$,
$m=1$, $A=\;180°-30°$,
$m=2$, $A=2.180°+30°$,
$m=3$, $A=3.180°-30°$, and so on.

Remembering that negative angles are measured in a clockwise direction, it will be seen that there will be negative angles which also have their sine equal to $\frac{1}{2}$. For instance, $-180°-30°$ is such an angle in the second quadrant and $-360°+30°$ is a negative angle in the first quadrant having this same sine. It will be seen that the general formula (i) for the solutions of sin $A=\frac{1}{2}$ will also include these negative values for when—

$m=-1$, $A=-1.180°-30°$,
$m=-2$, $A=-2.180°+30°$,

and so on.

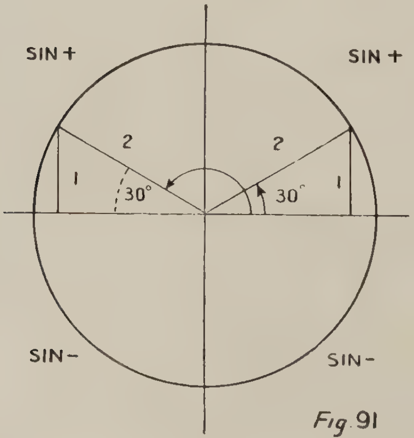


Fig 91

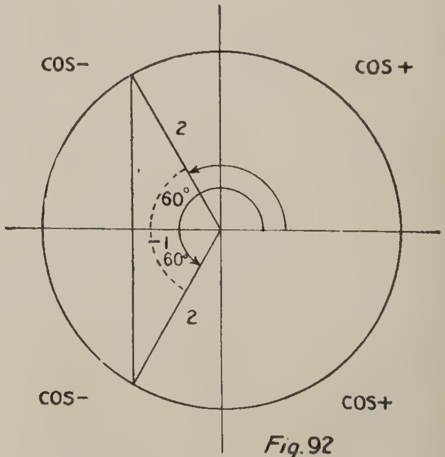


Fig. 92

EQUATIONS IN TRIGONOMETRY. *Fig. 91. Finding root values in the first and second quadrants for sin $A=\frac{1}{2}=30°$ (positive angles). Fig. 92. Finding angles that satisfy the equation sec $A=2$.*

We will now consider some other examples and in the first instance we shall find solutions only for a restricted range of values of the angle.

Example. Find all the angles between 0° and 360° which satisfy the equation

$$\sec A = -2.$$

If $\sec A = -2$, then this means that $\cos A = -\frac{1}{2}$ and since a cosine is negative only in the second and third quadrants, there can only be two solutions to our equation, one in each of these quadrants. From the diagram (Fig. 92) it is clear that the solution in the second quadrant is

$$A = 180° - 60° \text{ i.e. } 120°$$

and the solution in the third quadrant is $A = 180° + 60°$ i.e. 240°. These are the only solutions in the given range.

We may use the knowledge of quadratic equations gained in the last Lesson to help in the solution of trigonometrical equations if they can be put in the form of a quadratic equation in terms of any trigonometrical ratio.

Example. Solve the equation $\cot A = \tan A$ for values of A between 0° and 360°. (Note that this range may be written $0° < A < 360°$, meaning A greater than 0° but less than 360°.)

If $\cot A = \tan A$

then $\dfrac{1}{\tan A} = \tan A$

so that $\tan^2 A = 1$.

On taking the square root of both sides we have

$$\tan A = \pm 1,$$

thus there will be four solutions in the given range, for if $\tan A = +1$, we obtain a solution in the first quadrant (45°) and also in the third quadrant (180° + 45°). If we take the solutions given by $\tan A = -1$, we shall have one in the second quadrant (180° − 45°) and one in the fourth quadrant (360° − 45°). Finally, then, if

$\tan A = +1$, $A = 45°$ or $225°$,

if $\tan A = -1$, $A = 135°$ or $315°$.

All these four values are solutions of our original equation.

Example. Solve the equation

$$2 \sin^2 A = 3 \cos A$$

for the range $0° < A < 360°$.

We may obtain this equation wholly in terms of cosines by using the identity $\sin^2 A = 1 - \cos^2 A$.

Thus the equation becomes

$$2(1 - \cos^2 A) = 3 \cos A$$

i.e. $2 \cos^2 A + 3 \cos A - 2 = 0$.

This is now a quadratic equation in cos A exactly similar to $2x^2 + 3x - 2 = 0$. Therefore we may factorize the expression into

$$(2 \cos A - 1)(\cos A + 2) = 0,$$

so that either

$2 \cos A - 1 = 0$ or $\cos A + 2 = 0$

i.e. $\cos A = +\frac{1}{2}$ or $\cos A = -2$.

Since no angle can have a cosine numerically greater than 1 there can be no solutions of $\cos A = -2$, therefore we discard this factor. The only solutions of our equation will be given by the first factor.

If $\cos A = \frac{1}{2}$ then the solutions will lie in the first and fourth quadrants and since $\cos 60° = \frac{1}{2}$, our solutions are $A = 60°$, $A = 300°$.

Equations Involving Multiple Angles. If we are dealing with equations involving multiple angles we may be able to solve directly for the multiple angle or we may be able to use the transformations of products and sums to provide us with an equation which can be factorized. We will work through a few examples.

Example. Solve the equation

$\tan 2A = 2$ for the range $0° < A < 180°$.

It will be clear that since we require solutions for A in the range 0° to 180°, we must consider values of 2A in the range 0° to 360°.

If $\tan 2A = 2$ there will be solutions of 2A in the first and third quadrants. The value in the first quadrant is obtained from a table of tangents: we find that $\tan 63° 26' = 2$, so that

$2A = 63° 26'$ (in the first quadrant)

or $2A = 180° + 63° 26'$ (in the third quadrant)

Thus $A = 31° 43'$ or $90° + 31° 43'$,

i.e. the solutions are $A = 31° 43'$, $A = 121° 43'$.

Example. Solve the equation

$$\sin 2A + \sin 4A = \sin 3A$$

for the range $0° \leqslant A \leqslant 180°$. (Notice that this means A is greater than or equal to 0° and less than or equal to 180°, i.e. a solution is required if it is either 0° or 180°.)

We may combine the L.H.S. of our equation into a product since we have already had the transformation

$$\sin A + \sin B = 2 \sin \tfrac{1}{2}(A + B) \cos \tfrac{1}{2}(A - B),$$

thus we obtain

$$2 \sin 3A \cos A = \sin 3A \quad . \; . \; . \; . \; . \; . \; . \; . \quad (ii)$$

The reader is particularly warned not to fall into the common error of supposing that at this stage the sin 3A occurring on both sides of our equation may be cancelled. Obviously $\sin 3A = 0$ will satisfy this equation and must not be disregarded. To avoid making this error, write (ii) as

$$2 \sin 3A \cos A - \sin 3A = 0,$$

so that we obtain

$$\sin 3A \, . \, (2 \cos A - 1) = 0.$$

Thus either $\sin 3A = 0$ or $2 \cos A - 1 = 0$. This provides two sets of solutions; if $\sin 3A = 0$ then $3A = 0$, 180°, 360°, 540°. We shall have to consider all these values because if the range for A is $0 \leqslant A \leqslant 180°$, then obviously the range for 3A is $0 \leqslant 3A \leqslant 540°$. The solutions arising from these values of 3A are found by dividing by 3, i.e. $A = 0$, 60°, 120°, 180°. In addition there are the solutions obtained from $2 \cos A - 1 = 0$, i.e. $\cos A = +\frac{1}{2}$. The only solution of this in the given range is $A = 60°$, so that in all there are four distinct solutions. Notice that if our range had been given as $0° < A < 180°$ there would only have been two distinct solutions, $A=60°$ and $A=120°$.

Example. Solve the equation

$$4\cos^2 A=2+\sin A\cos 2A,$$

giving all the solutions.

We may rewrite the equation as

$$\begin{aligned}\sin A\cos 2A&=4\cos^2 A-2\\&=2\,(2\cos^2 A-1)\\&=2\cos 2A \quad \text{i.e.}\end{aligned}$$

$$\cos 2A\,(\sin A-2)=0,$$

so that either $\cos 2A=0$, or $\sin A=2$.

There are no solutions to $\sin A=2$, since there is no angle which has its sine greater than 1 and therefore the only solutions to our equation are those given by $\cos 2A=0$. These are $2A=90°$, $180°+90°$, $360°+90°$, ... and may be included in the general formula

$$2A=90°+n.180° \quad \ldots\ldots\ldots\ldots \quad (iii)$$

where n has the values 0, 1, 2 . . . successively

$$\text{i.e.}\quad A=45°+n.90° \quad \ldots\ldots\ldots\ldots \quad (iv)$$

These give the positive values; the negative solutions of $\cos 2A=0$ are $2A=-90°$, $-180°-90°$, so that these are also included in (iii) by giving n the values $-1, -2$, ... and so on. Thus, (iv) gives *all* the solutions of our original equation; these solutions are in degrees. Expressed in radians they are given by the relation

$$\begin{aligned}A&=\frac{\pi}{4}+n\frac{\pi}{2}\\&=(2n+1)\frac{\pi}{4}\end{aligned}$$

where n is zero or any integer.

Equations of the Form $a\cos A+b\sin A=c$. There are two alternative methods for solving equations of this type.

(1) By transforming sinA and cosA into $\tan\frac{1}{2}A$ and solving the resulting quadratic in $\tan\frac{1}{2}A$, and

(2) by the use of a *subsidiary* angle. We will consider both methods and apply them to the same example.

Method (1). It will be remembered that we obtained identities for sin A and cos A in terms of tan ½A as follows:

$$\sin A=\frac{2\tan\frac{1}{2}A}{1+\tan^2\frac{1}{2}A} \text{ and } \cos A=\frac{1-\tan^2\frac{1}{2}A}{1+\tan^2\frac{1}{2}A}$$

The procedure will become clear by taking an actual example.

Example. Solve the equation

$$2\cos A+\sin A=1$$

for the range $0°<A<360°$.

If we write t for tan ½A and transform, this becomes

$$\frac{2\,(1-t^2)}{1+t^2}+\frac{2t}{1+t^2}=1$$

$$\begin{aligned}&\text{i.e.} && 2-2t^2+2t=1+t^2,\\&\text{or} && 3t^2-2t-1=0.\end{aligned}$$

This factorizes into

$$(3t+1)\,(t-1)=0,$$

so that either $3t+1=0$ or $t-1=0$,

i.e. $\tan\frac{1}{2}A=-\frac{1}{3}$ or $\tan\frac{1}{2}A=1$.

Since we require a range for A of 0° to 360° we require a range of ½A from 0° to 180°. From tables we find that $\tan 18°\,26'=+\frac{1}{3}$, so that $\tan(180°-18°\,26')=-\frac{1}{3}$,

i.e. $\frac{1}{2}A=161°\,34'$ is the only value in the range 0° to 180°,

i.e. $A=323°\,8'$ is the only solution from the first factor. From the second factor $\tan\frac{1}{2}A=1$, i.e. $\frac{1}{2}A=45°$ so that $A=90°$. Thus the only two solutions of our original equation are $A=90°$, $A=323°\,8'$.

Method (2). We may write the general equation

$$a\cos A+b\sin A=c$$

in the form

$$\frac{a}{\sqrt{a^2+b^2}}\cos A+\frac{b}{\sqrt{a^2+b^2}}\sin A=\frac{c}{\sqrt{a^2+b^2}} \quad (v)$$

Now if we choose a *subsidiary* angle B such that

$$\cos B=\frac{a}{\sqrt{a^2+b^2}},\ \text{then}\ \sin B=\frac{b}{\sqrt{a^2+b^2}}\ \text{and}$$

we shall have relation (v) in the form

$$\cos B\cos A+\sin B\sin A=\frac{c}{\sqrt{a^2+b^2}}$$

$$\text{i.e.}\qquad \cos(A-B)=\frac{c}{\sqrt{a^2+b^2}}$$

Also provided

$$c<\sqrt{a^2+b^2}$$

we can find from the tables the angle whose cosine is

$$\frac{c}{\sqrt{a^2+b^2}}$$

Knowing this angle and the angle B, we can find A. We illustrate this method with the same example:

$$2\cos A+\sin A=1$$

may be written

$$\frac{2}{\sqrt{5}}\cos A+\frac{1}{\sqrt{5}}\sin A=\frac{1}{\sqrt{5}}$$

We require to find the angle B such that—

$$\cos B=\frac{2}{\sqrt{5}}\ \text{and}\ \sin B=\frac{1}{\sqrt{5}}\ \text{i.e.}\ \tan B=\tfrac{1}{2}.$$

From tables, $B=26°\ 34'$, so that we have—

$$\begin{aligned}\cos(A-26°34')&=\frac{1}{\sqrt{5}}\\&=0{\cdot}4468\end{aligned}$$

and 0·4468 is the cosine of 63° 28′ or 360°−63° 28′. To consider any further values would obviously give A outside the range we require, thus

$$A-26°\ 34'=63°\ 28' \text{ or } 360°-63°\ 28'$$

so that

$$A=90°\ 2' \text{ or } 323°\ 6'.$$

It will be noticed that due to the trigonometrical tables there is a very slight discrepancy between the values obtained by the two methods.

The reader may wonder why we did not adopt what at first sight appears to be the obvious method of solving an equation of this type. We could have written the equation in the example as

$$2 \cos A = 1 - \sin A$$

and by squaring we would have obtained

$$4 \cos^2 A = (1 - \sin A)^2$$

or $\quad 4 (1 - \sin^2 A) = 1 - 2 \sin A + \sin^2 A$

and this can clearly be solved by rearranging as a quadratic in sinA. The disadvantage of such a method is that when we square both sides we bring in also the solutions of a different equation, namely

$$-2 \cos A = 1 - \sin A.$$

Consequently, if solutions were found this way, they would have to be put into the original equation and checked to exclude the solutions of this spurious equation.

EXERCISES

(1) Solve the following equations for values of A between 0° and 360°:

(i) $\cos A = -\frac{1}{2}$
(ii) $\operatorname{cosec} A = 2$
(iii) $2 \tan^2 A = 1$
(iv) $8 \cos^2 A = 9 - 6 \sin A$

(2) Give the general solutions of the following equations both in degrees and in radians.

(i) $\sin A = 0$
(ii) $\sin A = 1$
(iii) $\cos^2 A = 1$
(iv) $\tan^3 A = -1$

(3) Solve the following equations for the range $0° \leqslant A \leqslant 360°$:

(i) $\sin A + \sin 2A = 0$,
(ii) $\cos 4A + \cos 2A = 2 \cos^2 A$,
(iii) $\sin A + \cos A = \sin 3A + \cos 3A$,
(iv) $\cos 5A + \cos 3A = \cos A$.

(4) Show that the following equations have *no* real roots:

(i) $3 \sin A = 4 \operatorname{cosec} A$,
(ii) $\tan A + 5 \cot A + 2 = 0$,
(iii) $\sin 2A + 6 = 3 \sin A + 4 \cos A$.

(5) The following relations consist partly of identities and partly equations. Prove the identities and solve the equations, taking the range as $0° < A < 360°$:

(i) $2 \sin A = \sin 2A$,
(ii) $\sin 2A = 1 + \cos 2A$,
(iii) $4 \sin \frac{1}{2}A \cos \frac{1}{2}A = 1$,
(iv) $\sin^2 \frac{1}{2}A = (1 - \cos \frac{1}{2}A)(1 + \cos \frac{1}{2}A)$,
(v) $\sin A + \sin 2A = \sin 3A$,
(vi) $\sin 3A = \sin A (1 + 2 \cos 2A)$.

(6) Find the general solutions of the equation:

$$\cos A - \sin A = \cos 2A$$

Answers to Exercises in Lesson 17

(1) (i) $x = 10$; (ii) $x = -1$; (iii) $x = 1\frac{1}{2}$.
(2) (i) $x = 6, y = -2$; (ii) $x = 5, y = 1$; (iii) $x = 5, y = 8$.
(3) (i) $x = -4, x = 7$; (ii) $x = -9, x = 8$; (iii) $x = 0, x = -12$; (iv) $x = 3$ (twice); (v) $x = 0, x = -1, x = -5$; (vi) $x = 3, x = \frac{1}{3}$.
(4) (i) $x = \frac{1}{2}(9 \pm \sqrt{13})$; (ii) $x = +6, x = -4\frac{1}{2}$; (iii) $x = \frac{1}{4}(5 \pm \sqrt{-39})$ i.e. imaginary roots.
(6) (i) sum $= -7/3$, product $= 11/3$
(ii) sum $= -1$, product $= -10$;
(iii) sum $= -2$, product $= 0$.

Roots in (i) are imaginary, in (ii) and (iii) are real.

(7) Four roots, $x = \pm 3, \pm 2$.

(8) Real root is $x = 3$, two imaginary roots are $x = \frac{1}{2}(-1\frac{1}{2} \pm \sqrt{-7})$.

(9) $x = 2, x = 4, x = -1$.

LESSON 19

The Binomial Theorem

THIS important mathematical method, first formulated by Newton, the greatest of English mathematicians, provides a method of calculating or approximating the value of any two terms (binomial means 'two names') raised to any power. It is widely used for transforming and simplifying algebraic expressions.

It can easily be verified by direct multiplication that

$$(1+x)^2 = 1 + 2x + x^2$$
$$(1+x)^3 = 1 + 3x + 3x^2 + x^3$$
$$(1+x)^4 = 1 + 4x + 6x^2 + 4x^3 + x^4$$
$$(1+x)^5 = 1 + 5x + 10x^2 + 10x^3 + 5x^4 + x^5.$$

If we care to take sufficient trouble it is clearly possible to obtain the coefficients of each power of x in the expression for $1+x$ raised to any given power.

Can we find a general expression to represent this process? Can we find the expansion of $(1+x)^n$ where n is any positive whole number? If we write:

$$(1+x)^n = 1 + ax + bx^2 + cx^3 + \ldots\ldots + x^n$$

can we find the numbers a, b, c, . . . in terms of n, so that these coefficients could be written down at once no matter how large n is?

A glance at the formulae given above gives us several clues to the general form.

The first term is of course always 1. The second term has, as coefficient, a number which is the same as the power to which $1+x$ is raised. We expect therefore that $(1+x)^n$ will commence with $1+nx$. The next term is much more difficult; it is the coefficient of x, multiplied by the coefficient of x just above it and divided by 2. Thus in $(1+x)^3$ the coefficient of x^2 is 6, and this is 3 (from $3x$) multiplied by 2 (from $2x$ above it) divided by 2. In the same way in $(1+x)^4$ the coefficient of x^2, viz., 6, is $4\times 3/2$, and in $(1+x)^5$ the coefficient of x^2 is $5\times 4/2$. Thus in the general case we may expect that the coefficient of x^2 is $n(n-1)/2$ so that the first three terms would be

$$1+nx+\frac{n(n-1)}{2}x^2.$$

The coefficient of x^3 can be built up in a similar way. We multiply the coefficient of x by the corresponding coefficient above it and again by the coefficient above that, and divide by 3×2 this time. This checks correctly for the cases we have worked out, for in $(1+x)^4$ the coefficient of x^3, viz., 4, is $4\times 3\times 2/3\times 2$; in $(1+x)^5$ the coefficient of x^3, viz. 10 is $5\times 4\times 3/3\times 2$. In general, therefore, we may expect the coefficient of x^3 to be $n(n-1)\,(n-2)/3\times 2$, and the first four terms in $(1+x)^n$ would run:

$$1+nx+\frac{n(n-1)}{2}x^2+\frac{n(n-1)\,(n-2)}{3\times 2}x^3.$$

The series of terms, therefore, would appear to be taking on a systematic form. Indeed it suggests that the next term is

$$\frac{n(n-1)\,(n-2)\,(n-3)}{4\times 3\times 2}x^4 \text{ and so on.}$$

We notice also that for the particular cases we have worked out the coefficients are the same running from the first term to the last as from the last to the first. It will not be difficult to show that this is precisely what happens with the coefficients we have tentatively built up. It remains of course to prove that the formula we have now constructed is actually the correct one. This we shall do. For this purpose we introduce the following symbols:

instead of writing $3\times 2\times 1$ we write $3\,!$
" " " $4\times 3\times 2\times 1$ " " $4\,!$

Generally, instead of writing,
$n(n-1)\,(n-2)\,\ldots\,3\times 2\times 1$ we write *n!* and this is read as *n factorial*, or *factorial n*.

Consider the following expression which we will call S_n, viz.

$$S_n=1+nx+\frac{n(n-1)}{2\,!}x^2+\frac{n(n-1)(n-2)}{3\,!}x^3+\ldots \quad (i)$$

Then, multiplying by x, we have

$$xS_n=x+nx^2+\frac{n(n-1)}{2\,!}x^3+\ \ldots\ldots\ldots \quad (ii)$$

Adding (i) and (ii),

$$(1+x)S_n=1+(n+1)x+\frac{(n+1)n}{2\,!}x^2 +\frac{(n+1)n\,(n-1)}{3\,!}x^3+\ldots$$

But the expression we have on the right is simply the original expression S_n with n replaced by $n+1$. This therefore we write S_{n+1}.

Thus

$$S_{n+1}=(1+x)S_n$$

If n is a positive integer, this relation will be true if for n we write in succession $n=0$, $n=1$, $n=2$, $n=3$, ...

Thus we have, noting that $S_0=1$ from (*i*) when $n=0$

$$S_1=(1+x)$$
$$S_2=(1+x)S_1$$
$$S_3=(1+x)S_2$$
$$\ldots\ldots\ldots$$
$$S_{n-1}=(1+x)S_{n-2}$$
$$S_n=(1+x)S_{n-1}$$

If we multiply all the terms on the left together and all the terms on the right together, we notice that $(1+x)$ occurs n times, and S_1, S_2, S_3 . . . . S_{n-1} cancel out on both sides. We are left finally with

$$S_n=(1+x)^n$$

and we have, therefore, if n is a positive integer,

$$(1+x)^n=1+nx+\frac{n(n-1)}{2\,!}x^2+\frac{n(n-1)\,(n-2)}{3\,!}+\ldots$$

This is called the *Binomial Theorem*.

Example. Let $n=6$, then

$$(1+x)^6=1+6x+\frac{6\times 5}{2\,!}x^2+\frac{6\times 5\times 4}{3\,!}x^3 +\frac{6\times 5\times 4\times 3}{4\,!}x^4+\frac{6\times 5\times 4\times 3\times 2}{5\,!}x^5+\frac{6\,!\,x^6}{6\,!}$$
$$=1+6x+15x^2+20x^3+15x^4+6x^5+x^6$$

If in the expression for the Binomial Theorem we write x/a in place of x we find

$$\left(1+\frac{x}{a}\right)^n=1+n\frac{x}{a}+\frac{n(n-1)}{2\,!}\,\frac{x^2}{a^2} +\frac{n(n-1)\,(n-2)}{3\,!}\,\frac{x^3}{a^3}+\ \ldots$$

But $\left(1+\frac{x}{a}\right)^n=(a+x)^n/a^n$.

Hence multiplying both sides by a^n we have

$$(a+x)^n=a^n+na^{n-1}x+\frac{n(n-1)}{2\,!}a^{n-2}x^2$$
$$+\frac{n(n-1)\,(n-2)}{3\,!}\,a^{n-3}\,x^3+\;.\;.\;.$$

In this a and x may have any values we please, but n must be a positive whole number.

Example. If $a=x=1$ then

$$1+n+\frac{n(n-1)}{2\,!}+\frac{n(n-1)\,(n-2)}{3\,!}+\,.\,.\,+n+1=2^n,$$

that is, the sum of the coefficients in the binomial expansion is 2^n.

Example. If $a=1$, $x=-1$, then

$$1-n+\frac{n(n-1)}{2\,!}-\frac{n(n-1)\,(n-2)}{3\,!}+\;.\;.\;.\;.=0.$$

Example. To estimate the value of $1{\cdot}01^7$ to five decimal places

$$(1{\cdot}01)^7=(1+0{\cdot}01)^7$$
$$=1+7\times0{\cdot}01+\frac{7\times6}{2\,!}\,({\cdot}01)^2$$
$$+\frac{7\times6\times5}{3\,!}\,({\cdot}01)^3+\;.\;.\;.$$

$$\begin{array}{l}=1{\cdot}00000\\ \quad{\cdot}07000\\ \quad{\cdot}00210\\ \quad{\cdot}000035\\ \hline \quad 1{\cdot}072135\end{array}$$

We have brought the expansion of $(1{\cdot}01)^7$ to an end at the term in $({\cdot}01)^3$ since subsequent terms cannot affect the fifth or even the sixth decimal place.

Pascal's Triangle. The coefficients in the expansion of $(1+x)^n$ can be found quickly by building up a triangular table devised by Pascal. Here it is:

1	1							
1	2	1						
1	3	3	1					
1	4	6	4	1				
1	5	10	10	5	1			
1	6	15	20	15	6	1		
1	7	21	35	35	21	7	1	
1	8	28	56	70	56	28	8	1

. . . .

In this, the first row 1 1 give the coefficients of $(1+x)^1$, the second row gives the coefficients of $(1+x)^2$ viz. $1+2x+x^2$, the third row those of $(1+x)^3$ viz. $1+3x+3x^2+x^3$ and so on.

The table is constructed as follows: The first column on the left is composed of 1's and each row finishes with 1. Each number thereafter is found by adding the number just above it to the number one place to the left of that above it. Thus in the second row 2 is 1 just above it, plus 1 to the left of this 1. In the fourth row 4 is derived from 3+1, and 6 from 3+3. In the seventh row corresponding to the coefficients of $(1+x)^7$, 21 is derived by adding 15 above it, to 6 to the left of 15; 35 is found by adding 20 above it to 15 to the left of this 20. In this way the table can quickly be extended to give the coefficients of $(1+x)^n$ for any moderate value of n.

The justification for this procedure clearly lies in a relation which can be shown to exist between the coefficient of x^n in $(1+x)^n$ and the sum of the coefficients of x^n and x^{n-1} in $(1+x)^{n-1}$. The relation is in fact a simple equality.

Application of the Binomial Theorem. Suppose we have to solve the equation

$$x^3-6x^2+11x-6=0\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;(i)$$

To do this we try first to factorize the L.H.S. by means of the Remainder Theorem. It is then easily found that the equation is equivalent to

$$(x-1)\,(x-2)\,(x-3)=0,$$

with roots $x=1$, $x=2$, $x=3$.

Suppose, however, the equation were not exactly (i) but, say,

$$x^3-6x^2+11x-6{\cdot}1=0\;\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;\;(ii)$$

the difference being simply that the last term is 6·1 in place of 6. It is then obvious that the solutions of (ii) must be only slightly different from 1, 2, 3.

Let us suppose then that $x=1+y$ where y is expected to be very small. This value of x must satisfy (ii); hence

$$(1+y)^3-6\;(1+y)^2+11\;(1+y)-6{\cdot}1=0.$$

By means of the Binomial Theorem we may write this:

$$(1+3y+3y^2+y^3)-(6+12y+6y^2)+11+11y$$
$$-6{\cdot}1=0$$

or $-0{\cdot}1+2y-3y^2+y^3=0\;.\;.\;.\;.\;.\;.\;.\;.\;.\;(iii)$

Now y is small in comparison with 1. It follows that y^2 must be still smaller since $y^2=y\times y$, where y is a fraction, means take only a fraction of y. In the same way y^3 is still smaller. Hence in equation (iii) let us tentatively assume that the terms $-3y^2$ and y^3 can be neglected in comparison with the others. Thus equation (iii) takes the approximate form

$$-0{\cdot}1+2y=0 \text{ i.e. } y=0{\cdot}05$$

We can now test whether we can neglect $-3y^2+y^3$; for with this value of $y=0{\cdot}05$, $-3y^2+y^3$ is 0·007625, which is less than 8 per cent of each of the other terms retained. Accordingly as a first approximation to a solution of equation (ii) we have

$$x=1{\cdot}05$$

For a closer approximation still we could repeat this process by replacing x in equation (ii) by $x=1{\cdot}05+z$, and neglecting terms of higher order than the first in the resulting equation.

Again, the remaining two roots of equation (ii) can be found approximately by inserting $x=2+y$ and $x=3+y$ respectively in the equation since the solutions cannot be far removed from 2 and 3.

Thus inserting $x=2+y$ into equation (ii),

$$(2+y)^3-6\,(2+y)^2+11\,(2+y)-6{\cdot}1=0$$

Expanding by the Binomial Theorem and neglecting all terms in y beyond the first we have:

$$8+12y-6\ (4+4y)+11\ (2+y)-6{\cdot}1=0$$

i.e. $$-y-0{\cdot}1=0$$

Thus

$$y=-0{\cdot}1$$

and the approximate root is

$$x=2+y=1{\cdot}9$$

Again, for the solution which is close to $x=3$ we write $x=3+y$ and insert in equation (ii). Thus:

$$(3+y)^3-6\,(3+y)^2+11\,(3+y)-6{\cdot}1=0$$
$$27+27y-54-36y+33+11y\ -6{\cdot}1=0$$
$$2y-0{\cdot}1=0$$

i.e. $$y=0{\cdot}05$$

Hence $$x=3+y=3{\cdot}05$$

is the approximate solution.

EXERCISES

(1) Write down the expansions:

(i) $(1+x)^4$,
(ii) $(a-b)^5$,
(iii) $(y+y^{-1})^6$.

(2) By expanding $(1+x)^7$, check that the sum of the coefficients is 2^7.

(3) By using the Binomial Theorem evaluate $(1{\cdot}11)^8$ correct to 4 places after the decimal point.

(4) Show by expanding $(1-x)^4$ and $(1+x)^4$ by the Binomial Theorem, and multiplying the results together that the final result is the same as expanding $(1-x^2)^4$ by the Binomial Theorem.

(5) Write down the first five terms in the expansion of $(x+y)^{12}$.

(6) Show that the approximate value of $(1-x)^7\,(1+x)^4\,(1-2x)$ is $1-5x+5x^2$ if powers of x above the second are negligible.

(7) Use the Remainder Theorem to factorize $x^3+x^2-14x-24$

Hence state an approximation to the positive root of

$$x^3+0{\cdot}9x^2-14{\cdot}1x-24=0$$

and find a closer approximation.

(8) Expand $(1-3x^4)\ (1-x^9)$, retaining only those terms as far as x^5.

(9) Find all the roots of the equation

$$x^3-6x^2+11{\cdot}2x-6=0$$

to one figure after the decimal place.

(10) Find a so that $x+3$ is a factor of

$$x^3+ax^2+4x+3,$$

and find the other factors. Calculate accurately to the first decimal place, the real root of

$$x^3+3{\cdot}9x^2+4x+3=0.$$

Answers to Exercises in Lesson 18

(1) (i) 120°, 240°; (ii) 30°, 150°;
(iii) 45°, 135°, 225°, 315°;
(iv) 14° 29′, 30°, 150°, 165° 31′.

(2) (i) m, 180° or m π radians;
(ii) m. 360° + 90° or $(4\text{m}+1)\frac{\pi}{2}$ radians.
(iii) m. 180° or m π radians;
(iv) m. 180° − 45° or $(4\text{m}-1)\frac{\pi}{4}$ radians.

(In each case m is zero or any integer.)

(3) (i) 0°, 120°, 180°, 240°, 360°;
(ii) 0°, 90°, 180°, 270°, 360°;
(iii) 0°, 22½°, 112½°, 180°, 202½°, 292½°, 360°;
(iv) 15°, 75°, 105°, 165°, 195°, 255°, 285°, 345°.

(5) (i) Equation: 180°;
(ii) Equation: 45°, 90°, 225°, 270°;
(iii) Equation: 30°, 150°;
(iv) Identity;
(v) Equation: 120°, 180°, 240°;
(vi) Identity.

(6) $2\text{m}\pi,\ (4\text{m}+1)\frac{\pi}{2},\ (4\text{m}+1)\frac{\pi}{4}$ radians.

LESSON 20

Algebraic Geometry: First Steps

LET us review, for a few moments, the course that our mathematical studies has taken so far. We began with arithmetic and geometry, the ideas of number and shape, and from these beginnings we developed new branches; the arithmetic became generalized as we pursued the study of algebra, the geometry became more definite with the ideas of trigonometry. Now we are going to link up the subjects of algebra and geometry because, although we have not yet noticed it, they have a very close affinity.

This may be seen by considering the following simple example. Suppose we have two lines at right angles and a whole

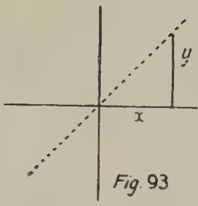


Fig. 93

series of points which are equidistant from both these lines (Fig. 93), then if we choose the lines at right angles to be coordinate axes as in Lesson 9, it is clear that for every one of our points the x coordinate is equal to the y coordinate. In addition it is clear that a straight line will pass through all our points; also for every point on this line we shall have the relation

$$y \text{ coordinate} = x \text{ coordinate} \quad . \; . \; . \; . \; . \; (i)$$

Again, it is evident that this relation will not be true for any point which does not lie on our straight line; so that relation (i) fixes a particular straight line. We may rewrite this relation more simply as

$$y = x,$$

an algebraic equation which defines a geometrical line.

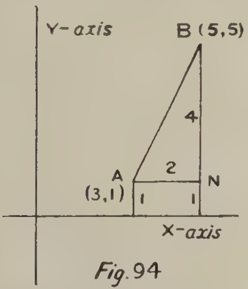


Fig. 94

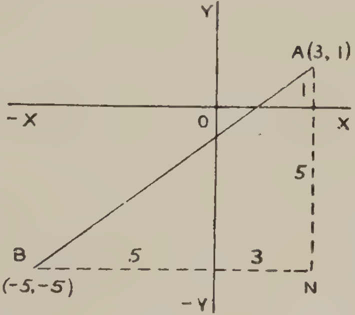


Fig. 95

Figs. 94 and 95. Given coordinates, how to find the length of lines joining them.

We have now an inkling of the connexion between the two subjects, and thus we are on the threshold of a new branch of study, the subject of *algebraic geometry*, or *coordinate geometry* as it is frequently termed because of the use that is made of the idea of coordinates. We introduced this idea in Lesson 9 and it is evident that we must consider this use of coordinates in more detail.

Distances Between Points. If the coordinates of two points are given, we may easily find the length of the straight line joining them. Consider an actual example. To find the length of the straight line joining (3, 1) to (5, 5). In problems on coordinate geometry it is always of great help to draw a rough diagram as in Fig. 94. If A, B represent the two points and AN is drawn parallel to the X-axis, it is clear that the length of AN is the x coordinate of B – the x coordinate of A, i.e. 2 units. Similarly BN is the y coordinate of B – the y coordinate of A, i.e. 4 units. Thus, from the Theorem of Pythagoras

$$AB^2 = 4^2 + 2^2 = 20, \text{ i.e. } AB = \sqrt{20}.$$

Consider one more example. To find the distance of (3, 1) from (–5, –5). Draw a diagram (Fig. 95) and construct the right-angled triangle ABN as in the last example. It is clear that BN is numerically equal to 3+5, i.e. 8, and AN is numerically equal to 1+5, i.e. 6 units. Thus:

$$AB = \sqrt{(8^2 + 6^2)} = \sqrt{100} = 10 \text{ units.}$$

Division of a Line in Any Ratio. If we know the coordinates of the ends of a straight line we may use similar triangles to find the coordinate of a point dividing this line in any ratio. Suppose A is the point (3, 6) and B the point (–7, 1) and we require the coordinates of a point P such that AP/PB = 2/3 (Fig. 96). Draw AN and BN parallel to the Y and X axes respectively and do similarly with PM and PL. Now BN = 3+7, i.e. 10 units, and AN = 6–1, i.e. 5 units. From similar triangles PM/AN = BP/BA

i.e. $$\frac{PM}{5} = \frac{3}{5}$$

i.e. $$PM = 3 \text{ units.}$$

The y coordinate of P = PM+1 because M is at a distance of 1 unit from the axis of X, i.e. y coordinate of P = 4 units.

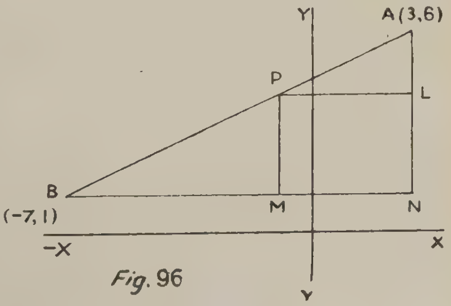


Fig. 96

COORDINATE GEOMETRY. Fig. 96. Given coordinates, how to divide a line in any ratio.

Similarly

$$PL/BN = AP/AB$$

i.e. $$\frac{PL}{10} = \frac{2}{5}$$

i.e. $$PL = 4 \text{ units.}$$

But L is 3 units from the Y axis, therefore the x coordinate of P is -1, i.e. P is the point $(-1, 4)$.

Areas. If we know the coordinates of the vertices of a triangle or any other figure, its area may be easily calculated. Again an actual example will suffice to explain the method.

Example. To find the area of the triangle formed by joining the three points (1, 1), (3, 5) and (7, 3). ABC (Fig. 97) represents the triangle, and through its vertices are drawn lines parallel to the axes, thus making a rectangle round the sides of which have been placed numbers representing the lengths of the various portions found from the coordinates of the vertices.

The three figures in circles denote the areas of the three right angled triangles formed, in square units. The area of the whole rectangle is 6×4, i.e. 24 square units, so that the area of ABC is $24-4-4-6 = 10$ square units.

Straight Lines. In the early part of this Lesson (p. 251) we found the equation which represented a particular line; the equation was $y = x$, the line bisected the angle between the axes and passed through the *origin* (the point of intersection of the axes). We may well ask: what line is represented by the equation $y = x+1$ or by $y = x-1$ or by $y = \frac{1}{2}x$?

This will not be difficult to discover, for we have only to plot a few points whose coordinates satisfy the equation to see the position of the line. Thus (Fig. 98) for the line $y = x+1$, when $x = 0$, $y = 1$, when $x = 1$, $y = 2$, and when $x = 2$, $y = 3$, and so on, so that we find that $y = x+1$ represents another straight line parallel to that given by $y = x$ but above it.

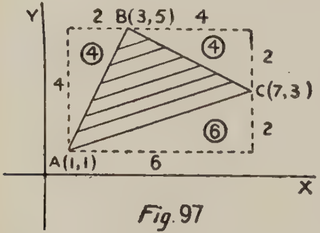


Fig. 97

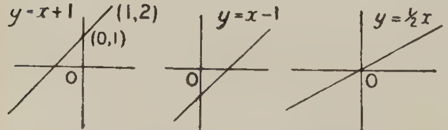


Fig. 98

The lines represented by $y = x-1$ and $y = \frac{1}{2}x$ are also shown; notice that the line defined by $y = \frac{1}{2}x$ is closer to the horizontal than the others. The reader should try drawing some other lines, for example $y = x+2$, $y = 3x$, $y = \frac{1}{4}x$, $y = \frac{1}{4}x+1$, and two important facts emerge.

First, that $y = Ax$ (where A is any number, positive, negative or fractional) always represents a line passing through the origin and, secondly, that the value of A has some connexion with the angle that the line makes with the X-axis.

For instance, we know that when $A = 1$ the line is at 45° to the X-axis, and it will be found that when $A > 1$, the line is steeper and when $A < 1$ the line is less steep than $y = x$. Again, when A is negative the line will be in the second and fourth quadrants. More light will be thrown on this if we attempt to find the equation of *any* straight line.

Equation of a Straight Line. Take any straight line AB (Fig. 99) and choose any point P on it. Draw PN perpendicular to the x-axis. If O is the origin then ON, PN represent the x and y coordinates respectively of the point P. We shall denote them simply by x and y.

Our problem is thus to determine the relation between x and y which holds for the line AB and for no other line. Suppose that the angle which AB makes with the X-axis is represented by the Greek letter θ, then the line AB is still not fixed because any number of parallel lines may all be drawn making the same angle θ with the X-axis. If Q is the point of intersection of AB with the Y-axis, let $OQ = c$. Draw QM parallel to the X-axis, then—

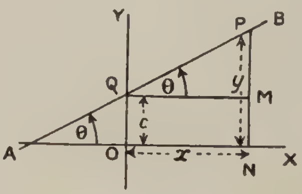


Fig. 99

$$PN = PM + MN,$$

$$= PM + OQ \text{ since OQMN is a rectangle,}$$

i.e $$y = PM + c \quad \ldots\ldots\ldots\ldots \quad (i)$$

Also $$\frac{PM}{QM} = \tan\theta, \text{ and } QM = ON = x;$$

thus $$PM = x \tan\theta,$$

Fig. 97. Finding the area of a triangle.
Figs. 98 and 99. Equations for straight lines.

and (i) becomes

$$y = x \tan \theta + c \quad . \; . \; . \; . \; . \; . \; . \; . \quad (ii)$$

This, then, is the equation to AB, and if $\tan \theta$ (termed the *slope* or *gradient* of AB) be written as m, (ii) becomes

$$y = mx + c \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (iii)$$

This is the fundamental equation to a straight line; it represents any particular straight line in terms of its slope (m) and its intercept on the Y-axis (c), provided that we always measure θ as the angle made with the positive X-axis.

Example. Find the equation to the straight line passing through $(-1, 0)$ and $(0, -2)$.

If a rough sketch is made it will be seen that this line cuts both the negative X and negative Y-axes, and consequently c (the intercept on the Y-axis) is -2. Also $\theta > 90°$ so that $\tan \theta$ is negative, its numerical value being $\frac{2}{1}$ i.e. $m = -2$. Therefore the equation to this line is $y = -2x - 2$.

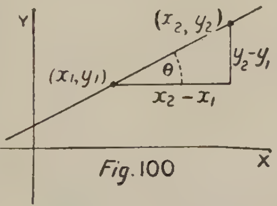


Fig. 100. Equation for a line joining two given points.

Equation of a Line of Given Slope Through a Fixed Point. If the slope of a straight line is given and the coordinates of a point in it are known, then the straight line is completely fixed so that we must be able to find its equation in terms of these fixed quantities. It is convenient to denote the coordinates of a fixed point in general terms by (x_1, y_1), then if the given slope is m, the equation to our line is

$$y = mx + c \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (iv)$$

Since this line is to pass through the fixed point (x, y), these coordinates must satisfy relation (iv); hence

$$y_1 = mx_1 + c \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (v)$$

Subtracting (v) from (iv) we obtain

$$\begin{aligned} y - y_1 &= mx - mx_1 \\ &= m(x - x_1) \quad . \; . \; . \; . \; . \; . \; . \; . \quad (vi) \end{aligned}$$

Example. To find the equation of the straight line passing through $(-3, 7)$ such that the angle (θ) which it makes with the X-axis is given by $\tan \theta = 2$.

Here $m = 2$, so that the general equation of any straight line (iii) becomes in this case

$$y = 2x + c \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (vii)$$

This has to pass through the point $(-3, 7)$ so that (vii) must be satisfied by $x = -3$, $y = 7$

i.e. $7 = 2(-3) + c$

This gives $c = 13$ directly so that (vii) becomes

$$y = 2x + 13.$$

We may obtain the same result by using the general equation (vi), for

$$\begin{aligned} y - 7 &= 2(x + 3) \\ \text{i.e.} \quad y &= 7 + 2x + 6 \\ &= 2x + 13. \end{aligned}$$

Equation of a Line Joining Two Known Points. Suppose the coordinates (x_1, y_1), (x_2, y_2) of two points are known. Then from the diagram (Fig. 100) it is clear that—

$$m = \tan \theta = \frac{y_2 - y_1}{x_2 - x_1}$$

so that equation (vi) may be written:

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1) \quad . \; . \; . \; . \; . \; . \quad (viii)$$

This equation, which is that of a line joining two known points, may also be found directly by the repeated use of the fundamental equation $y = mx + c$. Consider an example.

Example. Find the equation of the straight line joining the points $(3, 4)$ and $(-3, -1)$.

Since both these points must, in turn, satisfy the equation $y = mx + c$ we obtain

$$4 = 3m + c \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (ix)$$

and

$$-1 = -3m + c \quad . \; . \; . \; . \; . \; . \; . \; . \quad (x)$$

Adding these two equations

$$3 = 2c, \text{ i.e. } c = \frac{3}{2}$$

and subtracting (x) from (ix)

$$4 - (-1) = 3m - (-3m), \text{ i.e. } 6m = 5 \text{ or}$$

$$m = \frac{5}{6}.$$

Thus $\quad y = mx + c$ becomes $y = \frac{5}{6}x + \frac{3}{2}$ or

$$6y = 5x + 9.$$

This is the equation to our required line and it may be written down immediately by using the general equation (viii). Taking (x_1, y_1) as the point $(3, 4)$ and (x_2, y_2) as $(-3, -1)$, equation (viii) becomes—

$$y - 4 = \frac{-1 - 4}{-3 - 3}(x - 3)$$

i.e. $\quad y - 4 = \frac{5}{6}(x - 3)$

or $\quad 6y = 24 + 5x - 15$, i.e. $6y = 5x + 9$.

Point of Intersection of Two Lines. If we know the equations of two straight lines we may find the coordinates of their point of intersection (provided the lines are not parallel) simply by solving the two equations together, i.e. by treating the two equations as simultaneous. The reason for this is that the point of intersection is the only point on both lines, i.e. its coordinates must satisfy both equations at the same time.

Example. Find the point of intersection of the lines represented by $y = x+1$ and $y = 2x+3$.

Treat these as simultaneous equations, thus :

$$y = x+1 \quad \dots\dots\dots\dots \quad (xi)$$
$$y = 2x+3 \quad \dots\dots\dots\dots \quad (xii)$$

Subtract (xi) from (xii)

$$0 = x+2, \text{ i.e. } x = -2.$$

Therefore, from (xi) $y = x+1 = -2+1 = -1$. Thus the point of intersection is $(-2, -1)$. The reader should draw these lines accurately and verify this result.

Angle Between Two Straight Lines. Consider the diagram (Fig. 101) ; it represents two straight lines which have the equations $y = m_1x + c_1$ and $y = m_2x + c_2$. These lines make angles θ_1 and θ_2 respectively with the X-axis, so that $m_1 = \tan\ \theta_1$ and $m_2 = \tan\ \theta_2$. We require to find the angle θ between these two lines. From geometry we know that the exterior angle θ_1 is equal to the sum of the two interior opposite angles (θ_2 and θ), thus

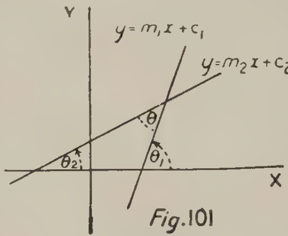


Fig. 101. Finding the angle between two lines.

$$\theta_1 = \theta_2 + \theta$$

so that

$$\theta = \theta_1 - \theta_2$$

therefore

$$\tan\ \theta = \tan\ (\theta_1 - \theta_2)$$

and we may use our knowledge of trigonometry to expand the R.H.S. Thus—

$$\tan\ \theta = \frac{\tan\ \theta_1 - \tan\ \theta_2}{1 + \tan\ \theta_1\ \tan\ \theta_2}$$
$$= \frac{m_1 - m_2}{1 + m_1\ m_2} \quad \dots\dots\dots \quad (xiii)$$

This gives the tangent of the angle between the two lines in terms of their slopes. We may find the angle between the two lines used in the last example, namely $y = 2x + 3$ and $y = x + 1$. Here

$$m_1 = 2,\ m_2 = 1$$

so that

$$\tan\ \theta = \frac{2-1}{1+1.2} = \frac{1}{3}$$

and from tables $\theta = 18^\circ\ 26'$. Notice that if we had taken $m_1 = 1$ and $m_2 = 2$ we should have found $\tan\ \theta = -\,{}^1/_3$ and then we would have found the obtuse angle between the two lines, i.e. $180^\circ - 18^\circ\ 26'$.

Relation (xiii) is very important since it enables us to find the relation which exists between the slopes of two lines if they are either parallel or at right angles. If two lines are parallel, $\theta = 0^\circ$ and so we must have

$$\frac{m_1 - m_2}{1 + m_1\ m_2} = 0, \text{ i.e. } m_1 - m_2 = 0$$

or $\quad m_1 = m_2.$

This states what we have already discovered, namely, that if two lines are parallel their slopes are equal. If, on the other hand, two lines are at right angles, then $\theta = 90^\circ$ and tan 90° is infinitely large. Therefore, in this case, we must have

$$\frac{m_1 - m_2}{1 + m_1\ m_2}$$

equal to an infinitely large number. This can only happen if the denominator approaches zero, since any number divided by a vanishing quantity is infinitely great. Thus, for two lines to be *perpendicular*

$$1 + m_1\ m_2 = 0$$

or

$$m_1 = -\frac{1}{m_2}$$

i.e. the slope of one line must be the negative reciprocal of the slope of the other. For example $y = \frac{1}{3}x + 7$ is at right angles to $y = -\ 3x + 4$ because $-\frac{1}{(-3)} = +\frac{1}{3}$.

EXERCISES

(1) Plot the points $(-4, 3)$, $(5, -6)$. Calculate the distance between them and check by measurement.

(2) Find by calculation the mid-point of the line joining $(-3, -4)$ to $(8, 7)$ and check by drawing.

(3) A triangle ABC has its vertices A, B, C at the points $(3, 0)$, $(-2, -1)$, $(0, 2)$. Find the lengths of AB, AC, BC and show that ABC is an isosceles, right-angled triangle. Find its area.

(4) In the previous question the square ABCD is completed : what are the coordinates of D ? Find the equations to the diagonals, prove that they are at right angles and find their point of intersection.

(5) Find the equations of the straight lines :
 (i) of slope 5 through the point $(1, 7)$;
 (ii) of slope $\frac{1}{2}$ through the point $(1, -3)$;
 (iii) of slope -3 through the origin.

(6) Show that the line joining $(1, 1)$ to $(-3, -1)$ is parallel to that joining $(4, 0)$ to $(0, -2)$.

(7) Show that the line joining $(-1, 3)$ to $(5, 1)$ is perpendicular to the line joining $(2, 2)$ to $(0, -4)$.

(8) Calculate the angle between the lines $2y = x+4$ and $x+4y = 20$ and find their point of intersection. Check these results by drawing.

(9) Find the equation to the line which is perpendicular to $y = 4x-3$ and passes through the point $(7, 3)$.

(10) Show that if the lines $y = m_1 x + c_1$ and $y = m_2 x + c_2$ are inclined at 45°, then $m_2 = \dfrac{m_1 - 1}{m_1 + 1}$.

Answers to Exercises in Lesson 19

(1) (i) $1 + 4x + 6x^2 + 4x^3 + x^4$,
(ii) $a^5 - 5a^4 b + 10a^3b^2 - 10a^2b^3 + 5ab^4 - b^5$
(iii) $y^6 + 6y^4 + 15y^2 + 20 + 15y^{-2} + 6y^{-4} + y^{-6}$

(3) 2·3044.

(5) $x^{12} + 12x^{11}y + 66x^{10}y^2 + 220x^9y^3 + 490x^8y^4$

(7) $(x+2)(x+3)(x-4)$: first approximation is $x = 4$, closer approximation is $x = 4{\cdot}0487$.

(8) $1 - 9x + 36x^2 - 84x^3 + 123x^4 - 99x^5$.

(9) $x = 0{\cdot}9$, $x = 2{\cdot}5$, $x = 2{\cdot}7$.

(10) $a = 4$, $x = -\frac{1}{2} \pm \frac{1}{2}\sqrt{-3}$, $x = -2{\cdot}9$.

LESSON 21

Problem Solutions: Lines and Circles

We have seen (Lesson 16) how the technician extracts the measurable features of a complex situation and how the mathematician subjects them to calculation.

What is Meant by Solution of a Problem ? Now there is a danger at this stage of which we must beware. Let us contrast the picture presented by the mathematician with the real situation. He examines a building. Its walls are, say, 30 ft. long by 10 ft. high. A door has to be inserted in one wall 3 ft. 6 in. wide and 6 ft. high, and two windows each 3 ft. by 4 ft. in another. The picture he presents to himself is one of rectangles bounded by idealized lines. In this way he can calculate the wall space—if it has to be whitewashed—the amount of wood required for door and windows and the amount of glass. He is concerned only with shape and size, and the result he finds is an absolutely correct answer *for his mathematical picture*.

The builder, the painter, carpenter, and glazier are made of different stuff, however. They have to deal with real walls, doors, and windows, not figments of the mathematician's imagination. They know the walls are not plane surfaces, that the edges are not mathematician's straight lines, but boundaries formed by bricks and mortar, and that the door, window-frames, and glass must have a certain amount of 'play' if they are to function. The mathematician's calculations therefore are wrong from their standpoint. It is not that they are not exact enough or that they are too exact ; it is simply that the mathematician has solved a *different problem*.

Practical and Mathematical Problems. It is not very different, however, but it is different. Two conclusions follow. First the practical men are glad to have the mathematician's calculation, but they have to readjust his results in the light of the 'give and take' with which they have to work. Secondly, the mathematician need not work out his problem with absolute accuracy. If he finds on calculation that the length of a certain beam is $\sqrt{5}$ ft. he may say this is exact for his picture, but as it stands it is not the solution for the practical man. Now

$$\sqrt{5} = 2{\cdot}23606 \ldots.$$

If the mathematician wants to suit the practical man, or if the practical man wants to use his mathematics he would not say that the length of the beam is $\sqrt{5}$ ft., but

2 ft., or 2·2 ft. or 2·24 ft. or 2·236 ft. or 2·2361 ft. according to the degree of detail with which the practical man works.

To say it is 2·2 ft. is to neglect 0·04 ft. approximately or about ½ in.

To say it is 2·24 ft. is to neglect 0·004 ft. approximately, or $\frac{1}{20}$ in., which is a reasonable amount for a carpenter to neglect in his measurements.

To say it is 2·236 ft. is to neglect 0·0001 ft. approximately, or about 1/1,000 in.

A sensible answer for the mathematician to provide, therefore, is not that the beam is $\sqrt{5}$ ft. long but that it is 2·24 ft. or 2 ft. $2\frac{15}{16}$ in. if the carpenter is working to sixteenths of an inch.

We can proceed a step farther in this discussion. The mathematician will often present, as the solution to a problem, a rather complicated formula asserting that this is the answer. As an answer to a mathematician it may be exemplary in the sense that from it he can derive a series of rather general propositions about the class of problem in question. It may provide the basis for a close study of the properties of the abstract problem he has posed to himself ; but it may in that form be of little use to the practical man. In the end the latter requires an answer in terms of definite numbers that he can set out as measurements or as a guide in practice. Finally, therefore, all formulae must be tabulated to some stated degree of accuracy in order that they may be reduced to a usable form ; and until the formula has been presented in this way it cannot be said adequately to represent the solution.

There is one last point. Since the mathematician's picture is necessarily a simplification of the hard reality from which it is drawn, the conclusions at which he arrives cannot be said to be proved *true* of the situation. They are attempts—perhaps groping attempts—to visualize the complexities of the real problem. In that sense therefore they must be placed on the same footing as an experiment—an attempt to find an adequate theory to explain what is happening.

LINES AND CIRCLES

The study of the straight line is of fundamental importance in coordinate geometry and we will consider some further properties. In Lesson 20 we derived the equation to any straight line in the form $y = mx+c$, i.e. in terms of its slope and its intercept on the Y-axis, and we used this equation to obtain various results. In this Lesson we will obtain the general equation to any straight line in various forms, these being more suitable for certain purposes.

Equation to a Straight Line in 'Intercept' Form. Suppose that a and b are the intercepts on the X and Y-axes respectively, made by any straight line (Fig. 102).

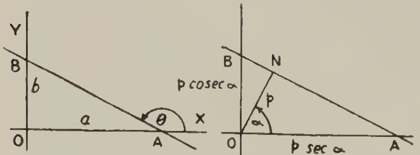


Fig. 102 *Fig.* 103

Figs. 102 and 103. Equations to straight lines in 'intercept' and in 'perpendicular' form.

Then it is a simple matter to obtain our general equation $y = mx+c$ in terms of the intercepts a and b. For the line we have drawn, $180° > \theta > 90°$, and so $\tan\theta$ is negative and numerically equal to b/a. Thus $m = -\frac{b}{a}$ and, in addition, the intercept on the Y-axis is b in this case. Thus the general equation $y = mx+c$ becomes :

$$y = \frac{-b}{a}x+b$$

or, dividing all through by b,

$$\frac{y}{b} = \frac{-x}{a}+1,$$

i.e. $$\frac{x}{a}+\frac{y}{b} = 1 \quad \dots\dots\dots\dots\dots \quad (i)$$

This is the equation to any straight line in terms of its intercepts on X and Y-axes.

We may use this equation to find the equations of lines parallel to the X and Y-axes. Suppose in Fig. 102 we keep the point B fixed and rotate our line anticlockwise. Then the intercept a will become greater and greater until when our line is parallel with the X-axis the intercept a will be infinitely large. We may obtain the equation to this line by making a become increasingly large in (i), because $\frac{x}{a}$ will then become zero, i.e. (i) will reduce to

$$\frac{y}{b} = 1 \text{ or } y = b.$$

This states that a line parallel to the X-axis, at distance $+b$ from it, has the equation $y = b$. Notice that this equation does not contain x and this is to be expected, for if our line is parallel to the X-axis, whatever the value of x, y is always the fixed distance b.

Similarly by keeping A fixed and rotating AB in a clockwise direction until it is parallel to the Y-axis, we shall have the intercept b becoming infinitely great and the equation (i) will reduce to $x = a$. Thus the equation to the X-axis is $y = 0$ and to the Y-axis is $x = 0$.

Equation to a Straight Line in 'Perpendicular' Form. Consider the diagram (Fig. 103). If we take a positive angle α, and a fixed distance p along the bounding line of this angle, we reach the point N which is therefore fixed in terms of p and α. Thus any line at right angles to ON is also fixed, so that we must be able to find the equation to this perpendicular line (AB) in terms of p and α. This method of writing the general equation to a straight line is known as the *perpendicular* or *normal* form. We may obtain the lengths of the intercepts OA and OB in terms of p and α from elementary trigonometry. Thus :

OA $\cos\alpha = p$ so that OA $= p\sec\alpha$, and
OB $\cos\angle$BON $= p$. But
$\angle$BON $= 90°-\alpha$, so that
$\cos\angle$BON $= \sin\alpha$,
i.e. OB $\sin\alpha = p$ or OB $= p \operatorname{cosec}\alpha$.

We have already found the equation to any straight line in 'intercept' form to be

$$\frac{x}{a}+\frac{y}{b} = 1,$$

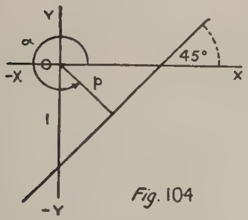
and now $a = OA = p \sec \alpha$ and $b = OB = p \operatorname{cosec} \alpha$, so we may write this equation in the form

$$\frac{x}{p \sec \alpha} + \frac{y}{p \operatorname{cosec} \alpha} = 1$$

i.e.
$$\frac{x \cos \alpha}{p} + \frac{y \sin \alpha}{p} = 1$$

or
$$x \cos \alpha + y \sin \alpha = p \quad . \; . \; . \; . \; . \qquad (ii)$$

This is the *perpendicular* form for the equation of any straight line, because it expresses the relation between x and y in terms of p and α.



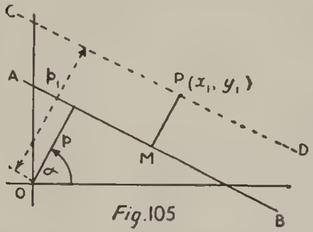


Fig. 104.* *Equation for a straight line $y = x - 1$ in 'intercept' and 'perpendicular' forms.* *Fig. 105.* *Finding length of perpendicular from P on to line AB.

Example. Express the equation of the straight line given by $y = x-1$ in 'intercept' and 'perpendicular' forms.

The form $y = x-1$ shows that the slope is 1, i.e. it makes an angle of 45° with the X-axis, and that the intercept on the Y-axis is -1. Thus the line is as drawn in Fig. 104. Since the X— intercept is $+1$ we may write the equation to the line in intercept form immediately as

$$\frac{x}{1} + \frac{y}{-1} = 1 \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \qquad (iii)$$

As shown in the diagram $\alpha = 360°-45°$, i.e. 315° and $p = 1 \cdot \cos 45° = \frac{1}{\sqrt{2}}$. Thus in 'perpendicular' form the equation becomes

$$x \cos 315° + y \sin 315° = \frac{1}{\sqrt{2}} \quad . \; . \qquad (iv)$$

It may easily be seen that (iii) and (iv) both reduce to our original equation $y = x-1$; they are only different *forms* of this equation. Equation (iii) reduces to $x-y = 1$, i.e. $y = x-1$ and since $\sin 315° = -\frac{1}{\sqrt{2}}$ and $\cos 315° = +\frac{1}{\sqrt{2}}$, equation (iv) reduces to

$$\frac{x}{\sqrt{2}} - \frac{y}{\sqrt{2}} = \frac{1}{\sqrt{2}}$$

i.e. $x - y = 1$ or $y = x - 1$.

Length of Perpendicular from a Point on to a Straight Line. We will suppose, in the first instance, that the equation to the straight line is given in perpendicular form, i.e. p and α are known and the equation is

$$x \cos \alpha + y \sin \alpha = p \quad . \; . \; . \; . \; . \qquad (v)$$

We require the length of the perpendicular on to this line from the given point (x_1, y_1). In Fig. 105, AB represents the given line, P the given point. The given quantities are p, α, and x_1, y_1, the coordinates of the given point. We will find the perpendicular length PM in terms of these four quantities. Suppose a line CD is drawn through the given point P, parallel to AB. For this line α will be the same as for AB, but the perpendicular length from the origin will be greater than p. Let this length be p_1, as shown on the diagram. Then the equation to CD is

$$x \cos \alpha + y \sin \alpha = p_1 \quad . \; . \; . \qquad (vi)$$

and since the given point (x_1, y_1) lies on this line, these coordinates must satisfy this equation and thus we have

$$x_1 \cos \alpha + y_1 \sin \alpha = p_1 \quad . \; . \; . \; . \; . \qquad (vii)$$

This relation determines p_1, in terms of the known quantities x_1, y_1, α. We may now obtain the length we require (PM), for

$$\begin{aligned} PM &= p_1 - p \\ &= x_1 \cos \alpha + y_1 \sin \alpha - p \quad \text{from } (vii), \end{aligned}$$

and everything on the R.H.S. is known.

Example. Find the length of the perpendicular from the point $(3, -2)$ on to the line $x \cos 315° + y \sin 315° = \frac{1}{\sqrt{2}}$

We may rewrite the equation to the straight line as

$$x \cos 315° + y \sin 315° - \frac{1}{\sqrt{2}} = 0$$

and then, from relation (vii) all we require to do to find the length of the perpendicular from $(3, -2)$ on to this line is to substitute 3 for x and -2 for y in the L.H.S. of this equation. Thus, in this example, the length of the perpendicular

$$\begin{aligned} &= 3 \cos 315° - 2 \sin 315° - \frac{1}{\sqrt{2}} \\ &= 3 \cdot \frac{1}{\sqrt{2}} - 2\left(-\frac{1}{\sqrt{2}}\right) - \frac{1}{\sqrt{2}} \\ &= \frac{4}{\sqrt{2}} \end{aligned}$$

The reader should check this result by plotting the point $(3, -2)$ and the given line and measuring the length of the perpendicular.

We have already seen that any equation of the form $y = mx+c$ involves making the coefficient of y unity; and although this is convenient for determining the slope of the line it is not necessary always to do this. Thus we may take, quite generally, the equation $Ax+By+C = 0$ to represent any straight line. This is much more common than the perpendicular form and we wish to deduce the length of a perpendicular from a point (x_1, y_1) on to the straight line when it is given in this form. Comparing the two forms together we have

$$x \,.\, \cos \alpha + y \,.\, \sin \alpha - p = 0 \qquad (viii)$$
$$x \,.\, A + y \,.\, B + C = 0 \quad \ldots\ldots \qquad (ix)$$

We cannot deduce from this that the coefficients of x in the two equations are equal because, obviously, $\cos \alpha$ is less than 1, whereas A may be any number, but we can say that there is a constant ratio between the coefficients of x, those of y, and the independent terms; thus

$$\frac{\cos \alpha}{A} = \frac{\sin \alpha}{B} = \frac{-p}{C} = k, \text{ say,}$$

$$\text{therefore } \cos \alpha = Ak \quad \ldots\ldots \qquad (x)$$
$$\sin \alpha = Bk \quad \ldots\ldots \qquad (xi)$$
$$\text{and} \quad -p = Ck \quad \ldots\ldots \qquad (xii)$$

From (x) and (xi) we can find k, for squaring and adding

$$A^2 k^2 + B^2 k^2 = \cos^2\alpha + \sin^2\alpha$$
$$= 1$$
$$\therefore \quad k^2 (A^2+B^2) = 1$$
$$\text{i.e.} \qquad k = \frac{1}{\sqrt{(A^2+B^2)}}$$

$$\text{so that } \cos \alpha = \frac{A}{\sqrt{(A^2+B^2)}}, \ \sin \alpha = \frac{B}{\sqrt{(A^2+B^2)}}$$

$$\text{and } -p = \frac{C}{\sqrt{(A^2+B^2)}}$$

Thus from (vii)

$$PM = x_1 \cos \alpha + y_1 \sin \alpha - p$$
$$= \frac{x_1 A}{\sqrt{(A^2+B^2)}} + \frac{y_1 B}{\sqrt{(A^2+B^2)}} + \frac{C}{\sqrt{(A^2+B^2)}}$$
$$= \frac{Ax_1 + By_1 + C}{\sqrt{(A^2+B^2)}} \quad \ldots\ldots\ldots \qquad (xiii)$$

so that we have the length of the perpendicular from a point (x_1, y_1) on to the line $Ax+By+C = 0$.

Notice that all we need to do, to find the length of the perpendicular is to replace the x and y of the general equation by the coordinates of the point from which we are to find the perpendicular, and divide by the square root of the sum of the squares of the coefficients of x and y.

Examples. Find the lengths of the perpendiculars from

(1) (5, 6) on to the line $3x+7y+10 = 0$,
(2) $(-3, -4)$ on to the line $x-5y-7 = 0$,
(3) the origin on to the line $3x-4y+20 = 0$.

(1) Length of perpendicular (from xiii) from (5, 6) on to $3x+7y+10 = 0$

$$= \frac{3\,(5)+7(6)+10}{\sqrt{(3^2+7^2)}}$$
$$= \frac{67}{\sqrt{58}}$$

(2) Length of perpendicular from $(-3, -4)$ on to $x-5y-7 = 0$

$$= \frac{-3 - 5\,(-4) - 7}{\sqrt{(1^2+5^2)}}$$
$$= \frac{10}{\sqrt{26}}$$

(3) Length of perpendicular from the origin on to $3x-4y+20 = 0$

$$= \frac{3(0)-4(0)+20}{\sqrt{(3^2+4^2)}}$$
$$= \frac{20}{5}$$
$$= 4$$

Regions. We have hitherto simply regarded the equation $Ax+By+C = 0$ as representing a straight line in a plane, but it is important to notice that this line will be the boundary between two *regions*, for one of which the function $Ax+By+C$ will be positive and for the other, negative. We may easily determine which is the positive and which the negative region by evaluating the function at a point definitely on one side or the other of the line $Ax+By+C=0$.

Consider Fig. 106 (*a*); here we have drawn the line $x-2 = 0$. To the right of this line (the shaded area), x is greater than 2, and therefore the function $x-2$ is positive and to the left of $x-2 = 0$, the function is negative. Thus $x-2 = 0$ is the boundary line between $x-2>0$ and $x-2<0$. Similarly in Fig. 106 (*b*). The line $y-x = 0$ is drawn. Evaluate $y-x$ for $x = 0$, $y = 5$ which represents a point definitely on the shaded side. With these values $y-x$ is $+5$, so that the shaded side indicates the region where $y-x$ is positive.

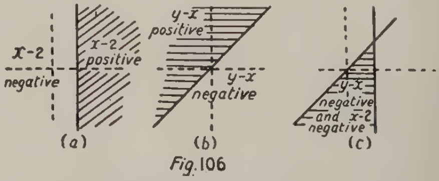


Fig. 106. *Straight line dividing the plane into positive and negative regions.*

In Fig. 106 (*c*) we have combined the two previous cases and the shaded area indicates the region where *both* $y-x$ and $x-2$ are negative.

Equation of a Circle. We will now consider the equation of a circle in the simple case where the centre of the circle is at the origin. A circle is defined in geometry as the path traced out by a point which moves so that it is always a fixed distance from a fixed point. The fixed distance is the radius and the fixed point is the centre. Now to find the equation to the circle, we require to find a relation between the coordinates of any point on the circle which is true for *all* points of the circle, but which is *not* true for any points *not* on the circle.

Suppose a point P on the circumference of the circle has coordinates (x_1, y_1), then since the centre of the circle is at the origin, we must have that $x_1^2+y_1^2 = r^2$ from the Theorem of Pythagoras, where r is the radius of the circle. This is the relation which exists between x_1 and y_1, the coordinates of a particular point on the circle and therefore the equation to this circle will be given by

$$(x \text{ coordinate})^2+(y \text{ coordinate})^2 = r^2$$

or more simply $x^2 + y^2 = r^2$

EXERCISES

(1) Draw the straight lines (i) $x+y = 0$, (ii) $2x+3y = 1$, (iii) $y-5 = 0$, (iv) $3y = 2-x$, (v) $x+2 = 0$. In each case check your drawing by choosing any point on the line, measuring its coordinates and verifying that they satisfy the equation.

(2) A is the point $(-2, 7)$ and O is the origin. Find the equation of OA.

(3) Find the equation to the line through $(-4, -2)$ parallel to the X-axis.

(4) Find the equation of a line making intercepts of 3 and 2 on the X and Y-axes respectively.

(5) Referring to Fig. 103, find the coordinates of A and B in terms of p and a, and hence obtain the equation to AB in perpendicular form by making both A and B satisfy the equation $y = mx+c$.

(6) Find the lengths of the perpendiculars from

(i) $(0, 8)$ on to the line
$$x \cos 30°+y \sin 30° = 3,$$
(ii) $(-3, 5)$ on to the line $3y+4x+7 = 0$,
(iii) $(1, 2)$ on to the line $7x-5y+3 = 0$,
(iv) (a, b) on to the line $x-y = 0$,
(v) $(-3, 7)$ on to the line $x = 0$.

(7) Determine the single region in which $x+y-7 < 0$, $y-4 < 0$, $y > 0$ and $x > 0$ at the same time and find its area.

(8) Draw the circle $x^2+y^2 = 9$. Choose any point on it, measure its coordinates, and check your drawing by verifying that these coordinates satisfy the equation of the circle.

Answers to Exercises in Lesson 20

(1) $9\sqrt{2}$ (or 12·726) ; (2) $(2\frac{1}{2}, 1\frac{1}{2})$;
(3) AB $= \sqrt{26}$, AC $= \sqrt{13}$, BC $= \sqrt{13}$. Area $= 6\frac{1}{2}$ sq. units ;
(4) D $(1, -3)$; $5y = x-3$ and $y = -5x+2$; $(\frac{1}{2}, -\frac{1}{2})$;
(5) (i) $y = 5x+2$; (ii) $2y = x-7$; (iii) $y = -3x$;
(8) 40° 36′ or 139° 24′, (4, 4) ;
(9) $4y+x = 19$.

LESSON 22

Lines and Conics

When we introduced the subject of algebraic geometry at the beginning of Lesson 20 we set out to discover the equation to the path traced out by a point moving in such a way that it was always the same distance from both the positive X and Y-axes. The path traced out by a point moving under certain conditions is called its *locus* and in this example we found that the locus of the point was a straight line whose equation was $y = x$.

Again, when we found the equation to a circle having its centre at the origin we were finding the equation to the locus of a point moving under the condition that it was always a fixed distance (the radius) from the origin.

This conception of a *locus* (plural, *loci*) is very important and we will consider here the general method of obtaining the equation to the locus of a point moving under any conditions. Suppose we imagine the point to be fixed, for the moment, at some particular point of its path, then in this position the point will have coordinates, say x_1 and y_1. Since the movement of the point is always subject to certain conditions, these will apply to x_1 and y_1 and so we may obtain from these given conditions the relation which must hold between x_1 and y_1. Thus we shall have a relation between the coordinates of a particular point which satisfies the given conditions, but we require to find the equation to a curve such that *all* points on it satisfy the given conditions. To do this, we only need to generalize the relation between x_1 and y_1, i.e. we write x in place of x_1 and y in place of y_1, so that we have the equation of a curve for *every* point of which, the given condition is satisfied. We illustrate this method by an example which obtains a result of practical importance.

To Obtain Equations of Bisectors of Angles between Two Straight Lines. Let

$$ax+by+c = 0$$

and $$a_1x+b_1y+c_1 = 0$$

represent the equations to the lines AB, CD respectively (Fig. 107). It is clear that if P (x_1, y_1) is a point on either of the bisectors of the angles between these two lines and if we draw perpendiculars PN and PM on to these lines then PN = PM. Thus each bisector is the locus of points which are equidistant from both AB and CD. We have already obtained (in Lesson 21) the length of the perpendicular from a point on to a line whose equation is $Ax+By+C = 0$ so that, using this result,

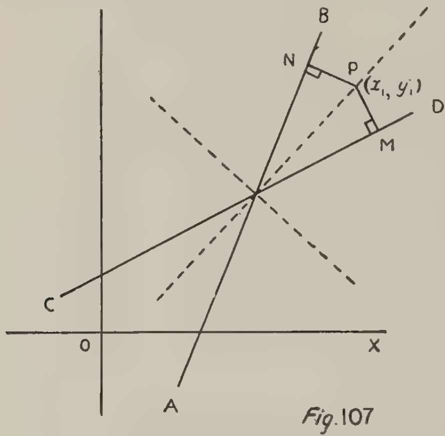


Fig. 107. Finding equations for bisectors of angles between straight lines.

$$PN = \frac{ax_1+by_1+c}{\sqrt{(a^2+b^2)}}$$

and $$PM = \frac{a_1x_1+b_1y_1+c_1}{\sqrt{(a_1^2+b_1^2)}}$$

If we equate these two lengths we are finding the relation between x_1 and y_1 in order that P shall lie on a bisector and if we replace x_1 and y_1 by x and y respectively we obtain the equation to the line which contains all such points, i.e. the equation to the bisector is

$$\frac{ax+by+c}{\sqrt{(a^2+b^2)}} = \frac{a_1x+b_1y+c_1}{\sqrt{(a_1^2+b_1^2)}} \quad . \; . \; . \quad (i)$$

Notice that since each denominator contains a square root which can be taken positive or negative, there will be two distinct cases; either both terms will be of like sign (positive or negative) or the terms will be of different signs (− and +, or + and −). By taking both possibilities we obtain the equations to the two bisectors of the angles between the original straight lines. Since a, b, c, a_1, b_1, c_1 are all constants (generally numerical), (i) must reduce to the form $Ax+By+C = 0$, i.e. it does correctly represent a straight line. The simplest way of deciding which sign in (i) gives which bisector is to draw a rough diagram and to see from this which bisector has a positive slope and which has a negative.

Example. Find the equations of the bisectors of the angles between the lines represented by $x+y = 4$ and $x=y+1$.

We may write the equations to these two lines in the form

$$y+x-4 = 0$$

and $$y-x+1 = 0$$

so that the equations of the bisectors, from (i), are

$$\frac{y+x-4}{\sqrt{(1^2+1^2)}} = \pm \frac{y-x+1}{\sqrt{(1^2+(-1)^2)}}$$

$$\frac{y+x-4}{\sqrt{2}} = \pm \frac{y-x+1}{\sqrt{2}}$$

This can be simplified by multiplying both sides by $\sqrt{2}$ and we obtain the two bisectors as

$$y+x-4 = +(y-x+1)$$

and $$y+x-4 = -(y-x+1)$$

i.e. $2x = 5$ and $2y = 3$

Thus the bisectors are the lines given by $x = 2\frac{1}{2}$ and $y = 1\frac{1}{2}$, i.e. they are parallel to the axes of X and Y in this case. Indeed this may be seen very easily from the fact that the slopes of the original lines are −1 and 1, i.e. the lines are inclined at 135° and 45° to the X-axis respectively.

The reader should verify the results obtained in this example by drawing the original lines and bisecting the angles between them geometrically.

General Equation of a Circle. We proceed to find the general equation of a circle by treating it as a locus problem. Let K (h, k) be the centre of the circle (Fig. 108) and P (x_1, y_1) any point on the circumference; then a circle will be traced out if P moves so that PK is constant. This constant distance is the radius of the circle (r) and we require the relation between

x_1 and y_1. If KN is drawn parallel to the X-axis, then KN is equal to the difference between the x-coordinates of P and K, i.e. KN $= x_1 - h$. Similarly PN is the difference in the y coordinates of P and K, i.e. PN $= y_1 - k$ and since KNP is a right-angled triangle, we have from the Theorem of Pythagoras that

$$(x_1-h)^2+(y_1-k)^2 = r^2$$

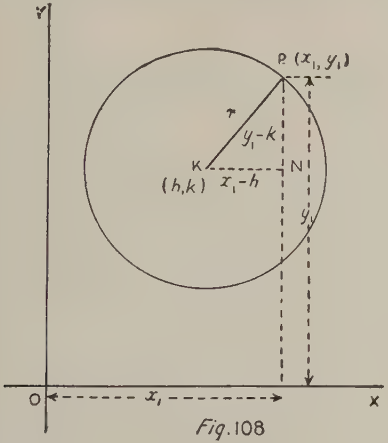


Fig. 108. ***The general equation of a circle of radius r, treated as a locus problem.***

This is the relation which exists between the coordinates of a particular point (P) on the circumference and hence the equation of the circle (which is to give a relation between the x and y coordinates of *any* point on the circumference) is

$$(x-h)^2+(y-k)^2 = r^2 \quad . \; . \; . \; . \; . \qquad (ii)$$

This is the general equation to a circle of radius r having its centre at the point (h, k) and working out the brackets we may write (ii) as

$$x^2-2xh+h^2+y^2-2yk+k^2 = r^2$$

or $$x^2+y^2-2xh-2yk+h^2+k^2-r^2 = 0 \, (iii)$$

This is sometimes a more convenient form than (ii).

Example. Find the equation of the circle having its centre at the point $(-3, 5)$ of radius 4.

From (ii) we may write the equation to this circle as

$$(x+3)^2+(y-5)^2 = 4^2$$

i.e. $$x^2+6x+9+y^2-10y+25 = 16$$

or $$x^2+y^2+6x-10y+18 = 0$$

Example. Find the centre and radius of the circle represented by $x^2+y^2+2x+4y-4 = 0$.

We may write this equation as

$$x^2+2x+y^2+4y = 4 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \qquad (iv)$$

and in order to find the centre of the circle we require to arrange that the terms in x and in y are both perfect squares. We must add 1^2 to x^2+2x and 2^2 to y^2+4y to make each of these expressions a perfect square, and in order not to alter the value of (iv) we must therefore add 1^2 and 2^2 to the R.H.S. also, so that (iv) becomes

$$x^2+2x+1+y^2+4y+4 = 4+5$$

i.e. $$(x+1)^2+(y+2)^2 = 3^2$$

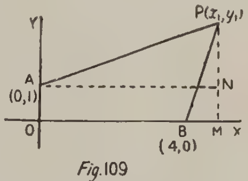
showing that the centre is at the point $(-1, -2)$ and the radius is 3.

It should be noticed from equation (iii) that the general equation of a circle must have the same coefficient of x^2 and y^2 and can contain no term in xy, so that we may write the general equation of a circle in the form

$$x^2+y^2+ax+by+c = 0$$

Example. A point P moves so that its distance from (0, 1) is twice its distance from (4, 0). Find the locus of P.

Consider Fig. 109; let A and B represent the points (0, 1) and (4, 0) respectively so that P (x_1, y_1) is one position of the point which roughly satisfies the given condition. This condition is that AP = 2 PB or, more conveniently, $AP^2 = 4\ PB^2$. It is a simple matter to obtain AP^2 and PB^2 in terms of x_1, y_1 and the coordinates of A and B. If perpendiculars PM and AN are drawn, then it is clear that



$$BM = x_1-4 \text{ and } PM = y_1 \text{ so that}$$
$$PB^2 = (x_1-4)^2+y_1^2$$

Again, $$AN = x_1 \text{ and } PN = y_1-1 \text{ so that}$$
$$AP^2 = x_1^2+(y_1-1)^2$$

The given condition is equivalent to

$$AP^2 = 4PB^2$$

or $$x_1^2+(y_1-1)^2 = 4[(x_1-4)^2+y_1^2]$$

which represents the relation between x_1 and y_1 in order that the given condition shall hold. Thus the equation to the locus of P is

$$x^2+(y-1)^2 = 4[(x-4)^2+y^2]$$

which simplifies into

$$x^2+y^2-2y+1 = 4\,(x^2-8x+16+y^2)$$

i.e. $$3x^2+3y^2-32x+2y+63 = 0 \; . \; . \; . \; . \; (v)$$

This is the equation we require; it represents a circle and we may proceed as in the last example to obtain its centre and radius, thus dividing (v) by 3 we have

$$x^2+y^2-\frac{32}{3}x+\frac{2}{3}y+21 = 0$$

or $$x^2-\frac{32}{3}x+y^2+\frac{2}{3}y=-21.$$

We need to add $\left(\frac{16}{3}\right)^2$ and $\left(\frac{1}{3}\right)^2$ to both sides in order to transform the L.H.S. into the sum of two perfect squares, then

$$\left(x-\frac{16}{3}\right)^2+\left(y+\frac{1}{3}\right)^2=\frac{256}{9}+\frac{1}{9}-21$$
$$=\frac{68}{9}$$

showing that the locus is a circle centre $\left(\frac{16}{3}, -\frac{1}{3}\right)$ and radius $\frac{1}{3}\sqrt{68}$, i.e $\frac{2}{3}\sqrt{17}$.

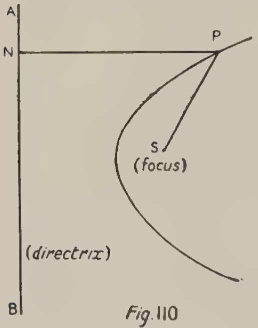


Fig. 110

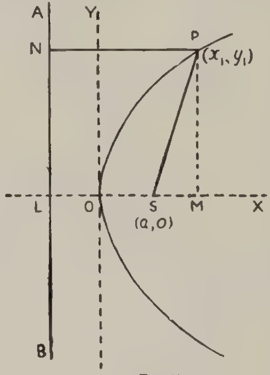


Fig. 111

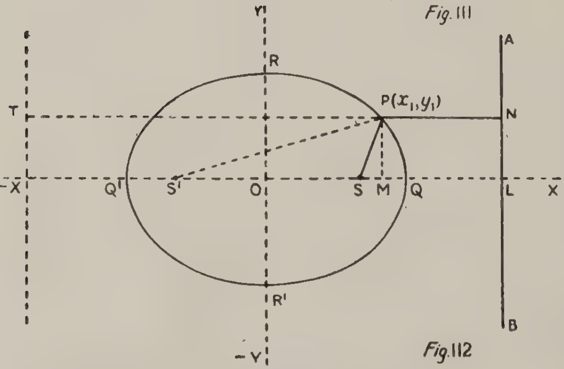


Fig. 112

CONIC SECTIONS. Fig. 110. Characteristics of a conic. Fig. 111. Constructing the equation for a parabola. Fig. 112. Calculating the equation for an ellipse with focus S and directrix AB.

Conic Sections. The locus of a point which moves in a plane so that its distance from a fixed point (called the *focus*) bears a constant ratio to its distance from a fixed line (called the *directrix*) is called a *conic section.* Consider Fig. 110: AB is a fixed line, S a fixed point so that for the locus of any point P to be a conic SP/PN = a constant. This constant is termed the *eccentricity* of the curve and is conveniently denoted by the letter e, so that

$$SP=e.PN \quad \ldots\ldots\ldots \quad (vi)$$

S is the focus and AB is the directrix. Three cases arise :

if $e=1$, the curve is a *parabola* ;
if $e<1$, the curve is an *ellipse* and
if $e>1$, the curve is a *hyperbola.*

Wherever we choose the X and Y-axes P will have some coordinates (say x_1, y_1), so that (vi) provides a condition which will give a relation between x_1 and y_1.

Thus we may use the same general method for obtaining the equation to a conic as we did for the circle in page 260.

The name conic section is derived from the fact that a cone may be cut by different planes to give all the types of curves. Notice that the definition of a conic section in no way depended on X or Y-axes : it was the statement of a geometrical relation. We only need axes and coordinates when we are attempting to describe a particular curve by means of an algebraic equation.

Equation of a Parabola. Referring again to Fig. 110, the curve will be a parabola if SP = PN i.e. if $e = 1$. Thus if a perpendicular SL is drawn from the focus S on the directrix AB, the mid-point of SL must be a point on the parabola, for then this point is equidistant from both S and L (Fig. 111). This is the most convenient point to take as the origin and if the direction of SL is taken as the X-axis, then a line through O, parallel to the directrix will be the Y-axis.

In addition, it is clear, we must take some constant to represent the x coordinate of the focus S. Let this be a. Then S is the point (a, o), L is the point ($-a$, o) so that the equation to the directrix is

$$x = -a.$$

If P (x_1, y_1) represents any point on the parabola, we may obtain the relation

SP=PN in terms of x_1, y_1, and a.
If $\quad SP = PN$
then $\quad SP^2=PN^2 \quad \ldots\ldots\ldots \quad (vii)$

It is clear that if PM is drawn perpendicularly to the X-axis, then

$$\begin{aligned} PN &= LM \\ &= LO+OM \\ &= a+x_1 \end{aligned}$$

and again,

since $MS=x_1-a$ and $PM=y_1$, we have
$$PS^2=(x_1-a)^2+y_1^2$$

Thus (vii) becomes

$$(x_1-a)^2+y_1^2=(x_1+a)^2$$

This is the relation between x_1, y_1 and a in order that P shall lie on the parabola, therefore the equation to this parabola is given by

$$(x-a)^2+y^2=(x+a)^2$$

i.e. $$x^2-2ax+a^2+y^2=x^2+2ax+a^2.$$

Since x^2 and a^2 cancel on both sides

$$y^2-2ax=2ax$$

i.e. $$y^2=4ax$$

This, then, is the equation of the parabola when the focus is the point (a, o) and the directrix is the line $x = -a$.

Equation of an Ellipse. For an ellipse (by definition) the eccentricity is less than 1. Let S be the focus and AB the directrix (Fig. 112) and as for the parabola, draw a perpendicular (SL) on to the directrix. Take the line containing SL as the X-axis. There must be a point Q between S and L such that

$$SQ=e.QL \quad \ldots\ldots\ldots \quad (viii)$$

and this point will be nearer to S than to L because $e<1$. Now there must also be a second point Q′ on LS produced such that

$$SQ'=e.Q'L \quad \ldots\ldots\ldots \quad (ix)$$

so that the ellipse must cut the X-axis in two points. Thus it is convenient to take the X-axis as the perpendicular bisector of the line joining these two points, i.e. the perpendicular bisector of QQ′, and so we have the origin (O) fixed. If we let OQ be represented by the letter a, then we may easily obtain the coordinates of S and L in terms of a and e.

Adding relations (viii) and (ix)

$$SQ+SQ'=e\,(QL+Q'L)$$

i.e. $$QQ'=e\,(OL-a+OL+a)$$

i.e. $$2a=e.2OL$$

and therefore $$OL=\frac{a}{e}$$

so that the directrix is the line

$$x=\frac{a}{e} \text{ and L the point } \left(\frac{a}{e},\ O\right)$$

Subtracting (viii) from (ix) we obtain

$$SQ'-SQ=e\,(Q'L-QL) \quad \ldots \quad (x)$$

Now $$SQ'=OQ'+OS=a+OS$$

and $$SQ=OQ-OS=a-OS$$

and therefore (x) becomes

$$a+OS-(a-OS)=e\,(QQ')$$

or $$2.OS=e.2a$$

i.e. $$OS=ae$$

Thus the focus is the point (ae, O).

We may now obtain the equation to the ellipse by taking P (x_1, y_1) as any point on it and expressing the geometrical relation $SP = e.PN$ in terms of x_1, y_1, a, e.

$SM=OM-OS=x_1-ae$, $PM=y_1$ and $PN=OL-OM=\frac{a}{e}-x_1$.

The relation $$SP=e.\,PN$$

is equivalent to $$SP^2=e^2.PN^2$$

i.e. $$SM^2+PM^2=e^2.PN^2$$

so that $$(x_1-ae)^2+y_1^2=e^2\left(\frac{a}{e}-x_1\right)^2 \quad (xi)$$

This is the relation between x_1, y_1, a and e and therefore the equation to the ellipse is

$$(x-ae)^2+y^2=e^2\left(\frac{a}{e}-x\right)^2$$

$$\text{or } x^2-2aex+a^2e^2+y^2=e^2\left(\frac{a^2}{e^2}-\frac{2ax}{e}+x^2\right)$$

$$= a^2-2aex+e^2x^2.$$

Thus $$x^2(1-e^2)+y^2=a^2\,(1-e^2)$$

or, dividing all through by $a^2\,(1-e^2)$

$$\frac{x^2}{a^2}+\frac{y^2}{a^2\,(1-e^2)}=1.$$

In this, we may for convenience write b^2 in place of $a^2\,(1-e^2)$ so that the equation to the ellipse becomes

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1 \quad \ldots\ldots\ldots\ldots \quad (xii)$$

We find the points where the ellipse cuts the Y-axis by putting $x = 0$ in (xii). We then have $y^2 = b^2$, i.e. $y = \pm b$, giving the points R, R′.

We may show that the ellipse is a closed curve passing through $x = \pm a$ and $y = \pm b$ by writing (xii) in the form

$$\frac{y^2}{b^2}=1-\frac{x^2}{a^2}.$$

Then if $x>a$, $\frac{x^2}{a^2}$ is greater than 1 so that the R.H.S. becomes negative, i.e. all values of y are imaginary if $x>a$.

QQ′ (equal to $2a$) is called the *major* axis of the ellipse and RR′ $(= 2b)$ is the *minor* axis, so that a and b are termed the *semi-axes* of the ellipse. It is clear from the symmetry of the ellipse that it must have a second focus (plural *foci*) S′ at the point $(-ae, O)$ and a second directrix (plural *directrices*) whose equation will be:

$$x = -\frac{a}{e}.$$

Drawing an Ellipse. There is an important property of an ellipse which enables it to be drawn very quickly. Consider Fig. 112 again:

$$SP = e.PN$$

and $$S^1P = e.PT.$$

Adding these two relations

$$\begin{aligned} SP + S^1P &= e\,(PN + PT) \\ &= e \times \text{ distance between the two directrices} \\ &= e.\ 2OL \\ &= e.\ \frac{2a}{e} \\ &= 2a, \text{ i.e. a constant.} \end{aligned}$$

Thus we may take a piece of string, stick drawing pins through it on to a piece of paper when these two points will be the foci of an ellipse drawn by a pencil which keeps the string taut.

EXERCISES

(1) A circle, centre (4, 1) and radius 2, cuts the X-axis in A and B. Draw the circle, measure AB and check by calculation.

(2) The straight line $3x-4y=1$ touches the circle whose centre is $(3, -3)$. Find the radius of the circle and confirm by drawing the line and circle.

(3) Draw the lines represented by $4x+3y=5$, $5x+12y=13$, measure the angle between them and read off the coordinates of the point of intersection. Check your drawing by calculating these values.

(4) Find the equations of the bisectors of the angles between the lines given in question (3) and from these equations show that the bisectors are at right angles.

(5) Find the equation of the circle whose centre is the point $(-2, -3)$ and which passes through the point (1, 1).

(6) Find the centre and radius of each of the following circles. Choose a point on each of the drawn circles, find its coordinates and check the correctness of your drawing by seeing if the coordinates of the point satisfy the equation of the circle.

(i) $x^2+y^2+2x-2y=0$,

(ii) $4x^2+4y^2-12x+8y=3$.

(7) A point moves so that its distance from the point (4, 0) is equal to its distance from the Y-axis. Find the equation to its locus and plot the curve.

(8) Find the equation to the parabola whose focus is the point (h, k) and directrix the line $x=l$.

(9) Find the lengths of the semi-axes, the eccentricity, the coordinates of the foci and the equation of the directrices of the ellipse $9x^2+25y^2=225$.

(10) Find the equation of the ellipse which has a focus at the point (1, 0), an eccentricity of $\frac{1}{2}$, and the directrix corresponding to this focus, the line $x=2$. Find also the coordinates of the other focus.

Answers to Exercises in Lesson 21

(2) $2y+7x=0$. (3) $y+2=0$. (4) $2x+3y-6=0$. (5) A $(p \sec \alpha, 0)$, B $(0, p \operatorname{cosec} \alpha)$.

(6) (i) 1, (ii) 2, (iii) 0, (iv) $\frac{a-b}{\sqrt{2}}$, (v) 3.

(7) A trapezium lying wholly in the first quadrant, area = 20 square units.

LESSON 23

Standard Curves: Graphical Solutions of Equations

In the last few Lessons on algebraic geometry we have obtained the equations to the straight line and a few important curves. Notice that in each case we started with the line or curve (or geometrical relation which defined it) and deduced, after fixing the coordinate axes, the algebraic equation representing the line or curve. In this Lesson we will reverse the procedure, i.e. being given an algebraic equation we will obtain the shape of the curve that it represents.

In theory there is a very simple way of doing this, for instance given the equation $y=f(x)$, we can substitute the values $x=0, 1, 2, \ldots -1, -2, -3, \ldots$ to obtain $f(0)$, $f(1)$, $f(2)$ and so on, which are the values of y at the corresponding values of x. Thus we may calculate a whole series of points lying on the curve $y=f(x)$ and by joining them up we shall have the shape of the curve.

Although this method is partly useful it has the great disadvantage that there is in general no guide to the range of values of x which must be taken in order to be sure of obtaining an accurate idea of the shape of the curve. In addition, this method may be very laborious and so we will develop some general methods which will enable us very rapidly to obtain an idea of the shape of the curve. This particular branch of study is known as *curve sketching* or *curve tracing*.

The Standard Curves. We begin by considering the graphs of simple functions in two groups: (1) $y=x, x^3, x^5; \ldots$ and (2) $y=x^2, x^4, x^6, \ldots$

(1) This group consists of the curves represented by y equals x raised to an odd power and thus it is clear that every one of these curves passes through the origin and in addition it lies in the first and third quadrants for y is positive when x is positive and when x is negative, x raised to an odd power is also negative, so that y is negative. Notice also that all curves of this type pass through the points (1, 1) and (−1, −1). Consider Fig. 113, where a few of these curves have been drawn; it is clear that when x is numerically greater than 1 the curves are steeper as their power is increased because $x^3 > x$, $x^5 > x^3$ and so on. On the other hand, when x is numerically less than 1, $x^3 < x$, $x^5 < x^3$, i.e. the curves are lower.

(2) If the power of x is even, then what ever the value of x, y is always positive so that these curves lie in the first and second quadrants. All the curves pass through three points: the origin, (1, 1) and (−1, 1). The same remarks regarding the relative positions of members apply, as in the first group. Fig. 114 shows two of these curves.

It should be noticed that if a constant appears in front of the term in x, e.g. $y=3x^2$, this simply implies that the scale of y is increased threefold, but the general nature of the outline is otherwise unaltered.

From these standard forms it is a very simple matter to deduce the shape of $y=-x^2$, $-x^3$, $-x^4$, ...we need only to draw the curves $y=x^2$, x^3, x^4 mirrored in the X-axis. We may use the foregoing information directly to sketch composite curves such as $y=x+x^2$ or $y=x^2-x^3$. Consider an actual example.

Example. Sketch the curve represented by $y=x^2+x^3$. We can very easily discover what is the shape of the curve $y=x^2+x^3$ for very small values of x and for very large values of x. By 'small values' is meant values of x small compared with 1. When x is less than 1 then $x^2 > x^3$ and therefore for values close to $x=0$ the x^3 term will be negligible compared to the x^2 term.

Thus $y=x^2+x^3$ will approximate to $y=x^2$ for very small values of x. Therefore we can draw a short curve (A) representing $y=x^2$ at the origin (Fig. 115).

For values of x large compared with 1, the curve $y=x^2+x^3$ will approximate to $y=x^3$ (because x^3 is very much greater than x^2 if x is very much greater than 1), i.e. we know that $y=x^2+x^3$ goes off 'to infinity' in a similar way to $y=x^3$. We may indicate by B and C these positions.

In addition $y=x^2+x^3$ may be put in the form $y=x^2\ (1+x)$ and therefore $y=0$ when $x=0$ (twice) or $x=-1$. We know then that the curve crosses the X-axis where $x=-1$ (indicated by the line D). Since x^2+x^3 must always be finite for values of x between 0 and −1, the part D must curve round to link up with the part A. It is reasonable to expect that A links up with B, and C with D.

Thus we have a very rough approximation to the shape of the curve: later we shall devise methods for examining the shape more exactly. We pass on now to the sketching of other types of curves.

Example. Sketch the curve represented by $y=(x-2)\ (x-3)$.

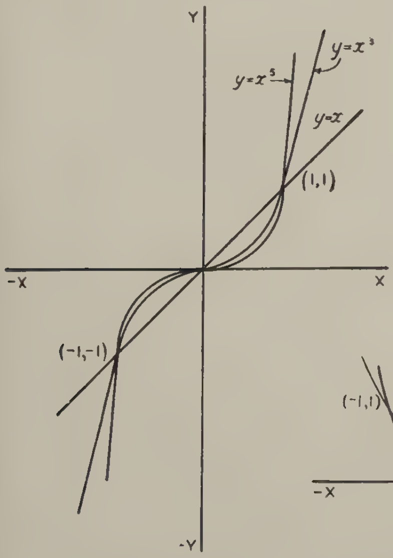


Fig. 113

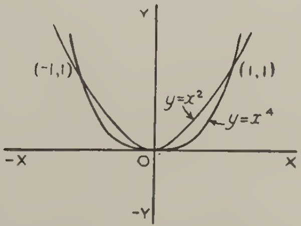


Fig. 114

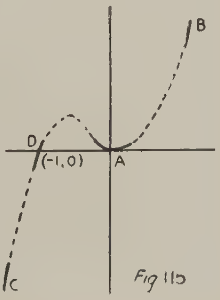


Fig 115

STANDARD CURVES. ***Fig. 113.*** ***Curves of Group 1*** $y=x^3$, x^5, ***etc.*** ***Fig. 114.*** ***Curves of Group 2*** $y=x^2$, x^4 . . . . ***Fig. 115.*** ***Sketching the Curve represented by*** $y=x^2+x^3$.

From the form of the quadratic function of x on the R.H.S. it is clear that $y=0$ when either $x=2$ or $x=3$. Since $(x-2)(x-3)$ is equivalent to x^2-5x+6 it is also clear that for values of x, numerically large compared with 1, x^2 is the most important term and the curve will approximate to that of $y=x^2$, i.e. it goes 'to infinity' in the first and second quadrants. Thus we have the information represented by the solid lines in Fig. 116, together with the fact that when $x=0$, $y=6$.

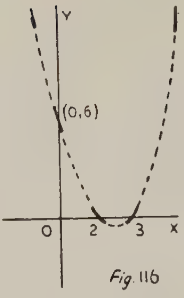


Fig. 116

As before, we join up as indicated by the dotted lines. Notice that we may find the minimum value of this function by writing

$$\begin{aligned} y&=x^2-5x+6\\ &=\left(x-\frac{5}{2}\right)^2+6-\frac{25}{4}\\ &=\left(x-\frac{5}{2}\right)^2-\frac{1}{4} \end{aligned}$$

We have simply used the technique of 'completing the square.' Since the term $\left(x-\frac{5}{2}\right)^2$ can never be negative, the minimum value of y occurs when $x-\frac{5}{2}=0$, i.e. when $x=2\frac{1}{2}$, the minimum value of y then being $-\frac{1}{4}$.

We can imagine what the shape of the curve would have been if we had been drawing $y=(x-2)(x-2{\cdot}1)$, for instance. Then we should have had two points on the X-axis very close together with only a tiny portion of the curve below the X-axis. Obviously then, the curve for $y=(x-2)^2$ will be similar in general shape to these first examples but the two points where the curve crosses the X-axis are coincident, i.e. they both occur at $x=2$, so that the X-axis is a tangent to the curve at this point.

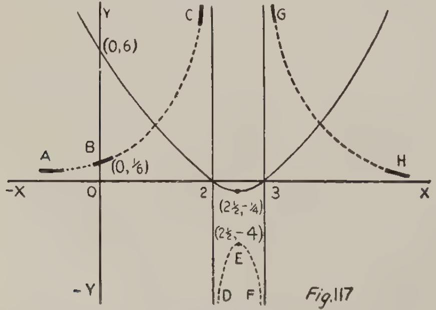


Fig. 117. *How a reciprocal curve is deduced from that of the original function.*

It thus becomes clear that if we draw the curve represented, in general, by $y=ax^2+bx+c$ that it cuts the X-axis in two points if $ax^2+bx+c=0$ has real roots, i.e. if $b^2>4ac$ (*see* Lesson 17), in two coincident points if $b^2=4ac$, and not at all if $b^2<4ac$, i.e. if the roots of $ax^2+bx+c=0$ are imaginary.

We may use the curve of

$$y=(x-2)\ (x-3)$$

to deduce the curve represented by

$$y=\frac{1}{(x-2)\ (x-3)}$$

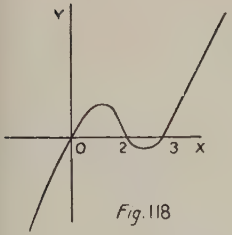
and the method is very important. It consists simply in noticing that when $(x-2)(x-3)$ is very large, then $\frac{1}{(x-2)(x-3)}$ must be very small and vice versa.

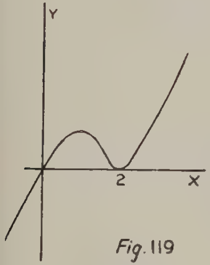
In Fig. 117 the curve of $y=(x-2)(x-3)$ has been drawn and also the two lines $x=2$, $x=3$. The dotted lines indicate the approximate shape of $y=\frac{1}{(x-2)(x-3)}$ and this shape is deduced as follows: A represents part of $\frac{1}{(x-2)(x-3)}$ which is positive but small, because the values of x in this position make $(x-2)(x-3)$ positive but large. When $x=0$, $(x-2)(x-3)$ is $+6$ and therefore $\frac{1}{(x-2)(x-3)}=+\frac{1}{6}$ (the point of B).

At a value of x just less than 2, $(x-2)(x-3)$ is very small but positive, i.e. $\frac{1}{(x-2)(x-3)}$ is very large and positive (this gives the part C). Since $(x-2)(x-3)$ is negative for all values of x between 2 and 3 $\frac{1}{(x-2)(x-3)}$ must also be negative, and so we deduce the loop DEF.

Notice that when x is just greater than 2, $(x-2)(x-3)$ is small and negative and therefore $\frac{1}{(x-2)(x-3)}$ is numerically large but negative. The point E $(2\frac{1}{2},-4)$ is determined since when $x=2\frac{1}{2}$, $(x-2)(x-3)=-\frac{1}{4}$. The part GH is deduced similarly to the part AC.

We may proceed to examine the shape of curves represented by y equal to a cubic function of x.





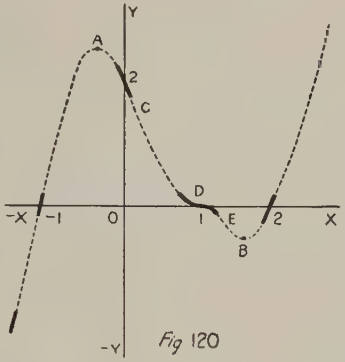


***Fig. 118.* Curve of cubic function of *x*. *Fig. 119.* Repeated root at $x = 2$. *Fig. 120.* Curve with treble factor $x-1$.**

Example. $y=x\,(x-2)\,(x-3)$.

We see immediately that $y=0$ when $x=0$, 2 or 3 and when x is numerically large the curve approximates to $y=x^3$, so that we deduce the shape to be as indicated in Fig. 118.

Repeated Roots. If we wish to draw $y=x\,(x-2)^2$, the same situation arises as when dealing with quadratic functions of x, we have what is termed a *repeated root* at $x=2$ so that the curve is as indicated in Fig. 119.

We may consider this question of repeated roots quite generally. Suppose we are sketching $y=f\,(x)$ and $f\,(x)$ contains a factor $(x-\alpha)^3$. Then when x is just less than α this term is negative, but when x is just greater than α, this term is positive, i.e. the value of y must change sign when x passes through the value α, so that the curve crosses the axis of X as well as touches it at the point α.

The same thing happens if we have a factor $(x-\alpha)^5$, $(x-\alpha)^7$, ... i.e. if $(x-\alpha)$ is raised to any odd power. If, on the other hand $(x-\alpha)$ is raised to an even power, the value of y does not change sign as x passes through α, so that in these cases the X-axis is a tangent to the curve at the point $x=\alpha$, but the curve does not cross the X-axis.

Example. Sketch the curve represented by $y=(x+1)\,(x-1)^3\,(x-2)$.

Here the factor $(x-1)$ occurs three times so that the curve touches the X-axis and crosses it at the point $x=1$. Also the curve crosses the X-axis when $x=-1$ and 2, and when x is large, the curve approximates to that of $y=x^5$. Thus we have the important features indicated by solid lines in Fig. 120. Notice also that when $x=0$, $y=2$.

The highest point A is termed a *maximum* position and we cannot yet find this maximum value of y nor the value of x at which this maximum occurs. The point B is a *minimum* position.

In addition, there are three points on the curve where the tangents to the curve change sides i.e. C, D and E; these points are known as *points of inflexion.*

Graphical Solution of Algebraic Equations. In cases where the roots of an equation cannot be determined accurately, it is often of great importance to be able to obtain approximate values or to be able to fix a range within which it can be stated definitely that a root occurs. There are some general methods which enable this to be done.

Suppose $f\,(x)=0$ represents an algebraic equation, then if two neighbouring values of x can be found by trial such that the value of $f\,(x)$ at these two positions is of different sign, then it is clear that there must be at least one root between the values of x. For instance, consider the equation:

$$x^3-10x+1=0\,;$$

if we write

$$f\,(x)=x^3-10x+1,$$

then by trial

$$f\,(0)=+1,\ \text{but}\ f\,(1)=-8.$$

These values indicate that if we plotted $y=f\,(x)$, at $x=0$, y would be negative and at $x=1$, y would be positive, so that there must be a value of x between 0 and 1 for which $y=0$ i.e. a point where the curve $y=f(x)$ crosses the X-axis

Thus there is a root of $x^3-10x+1=0$ between $x=0$ and $x=1$. Since $f\,(1)$ is numerically greater than $f\,(0)$ it is probable that the root lies nearer to $x=0$, so that we may then try $f\,(0{\cdot}2)$. The value of $f\,(0{\cdot}2)$ is negative, so that we now know that a root lies between $x=0$ and $x=0{\cdot}2$. By this trial and error method we may narrow the range within which x occurs until we establish the actual value of the root to any desired accuracy.

There is another important method. In the section on algebraic geometry, we established the fact that the point of intersection of two straight lines is obtained by solving their equations simultaneously. This is true also of lines and curves or even two curves. This fact is of use here. Consider the equation

$$x^3-10x+1=0.$$

This may be written as

$$x^3=10x-1$$

and if we draw the curve $y=x^3$ and the straight line $y=10x-1$, where they intersect will be points at which x^3 and $10x-1$ have the same value, i.e. the $x-$ coordinates of the points of intersection will be such that $x^3=10x-1$, i.e. these points provide information as to the approximate values of the roots.

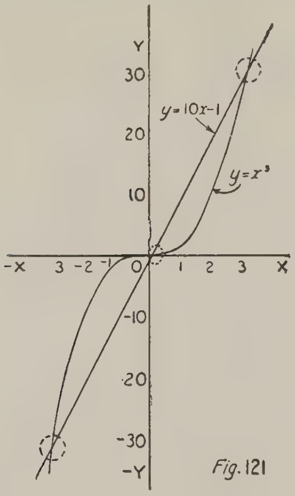


***Fig. 121.* Obtaining solutions of equations by graphical means.**

Consider Fig. 121, the curve $y=x^3$ is drawn and superimposed on it is the straight line $y=10x-1$. We see that there are three points of intersection and as nearly as we can estimate, they occur where $x=-3{\cdot}15$, $+0{\cdot}15$, $+3{\cdot}18$. In the diagram the points of intersection have been ringed, and it will be observed that the scale of y has been taken to be five times that of x. This is for convenience of drawing and will not affect the results obtained.

EXERCISES

(1) Sketch the curve $y=x^2-x^3$ and hence show that the equation $x^2-x^3=1$ has one negative root and no other real roots.

(2) Solve the equation $x^2-3x-5=0$ graphically. Check by calculation.

(3) Draw the graph of $y=x^2-3x+5$ and hence show that $x^2-3x+5=0$ has imaginary roots. Find the minimum value of x^2-3x+5 and find for what value of x this occurs.

(4) Show that the curve represented by $y=4x^2+4x+3$ does not cut the axis of X.

(5) Roughly sketch the curves

(i) $y=x(x-4)$,
(ii) $y=(2-x)(x-1)$,
(iii) $y=x^2(x-3)$,
(iv) $y=x(x-3)^2$,
(v) $y=x(x-2)^3$.

(6) Sketch the curves $y=x^2+2$ and $y=(x+1)(2-x)$. Hence deduce the curves representing $y=\dfrac{1}{x^2+2}$ and $y=\dfrac{1}{(x+1)(2-x)}$

(7) Draw carefully the graph of $y=x^3$ for values of x from -5 to $+5$, and by its aid solve

(i) $x^3=x+20$,
(ii) $x^3-10x-10=0$.

(8) Sketch the curve $y=(x^2+1)(x-2)$. Hence deduce that the equation $(x^2+1)(x-2)=1$ has only one real root, and that its value is just greater than 2. Put $x=2+h$ and find the root more accurately. Confirm by writing the equation in the form $x^2(x-2)=3-x$ and sketching $y=x^2(x-2)$ and $y=3-x$.

Answers to Exercises in Lesson 22

(1) $2\sqrt{3}$. (2) 4.

(3) 30° 31′ and 149° 29′, $\left(\frac{7}{11}, \frac{9}{11}\right)$

(4) $7y=9x$, $77x+99y=130$.

Slopes are $\frac{9}{7}$ and $-\frac{7}{9}$

(5) $x^2+y^2+4x+6y=12$.

(6) (i) Centre $(-1, 1)$, radius $\sqrt{2}$,
(ii) Centre $(1\frac{1}{2}, -1)$, radius 2.

(7) $y^2=8(x-2)$.

(8) $(y-k)^2=(h-l)(2x-l-h)$.

(9) $a=5, b=3, e=\frac{4}{5}$. Foci are at $(\pm4, 0)$.

Equations to directrices are $4x=\pm25$.

(10) $3x^2+4y^2=4x$, $(\frac{1}{3}, 0)$.

LESSON 24

The Binomial Theorem Developed

In earlier pages (Lesson 19) we have shown that an expression of the form $(1+x)^n$ where n is a positive whole number can be written in an alternative form in ascending powers of x, commencing with 1 and terminating with x^n. Now $(1+x)^n$ has a meaning for values of n other than a positive whole number. For example

$$\text{for } n=-1,\ (1+x)^{-1}=\frac{1}{1+x}\,;$$

$$\text{for } n=-2,\ (1+x)^{-2}=\frac{1}{(1+x)^2}\,;$$

$$\text{for } n=\tfrac{1}{2},\ (1+x)^{\frac{1}{2}}=\sqrt{(1+x)}\,;$$

$$\text{for } n=-\tfrac{1}{2},\ (1+x)^{-\frac{1}{2}}=\frac{1}{\sqrt{(1+x)}}\,.$$

On the other hand, the series which is the expansion of $(1+x)^n$ for n a positive whole number, viz:

$$1+nx+\frac{n(n-1)}{2!}x^2+\frac{n(n-1)(n-2)}{3!}x^3$$
$$+\ldots+\frac{n(n-1)(n-2)\ldots(n-r+1)}{r!}x^r+\ldots x^n$$

has no meaning as it stands for any value of n other than a positive integer, for the last term is x^n. If $n=\frac{1}{2}$, for instance, there could never be a final term $x^{\frac{1}{2}}$, since it could not occur anywhere in a development in ascending powers of x. The same would be true if n were -1 or -2, for there could be no term in x^{-1}, i.e. $1/x$ or x^{-2} i.e. $1/x^2$.

Are we to conclude then that there is no expression in ascending powers of x for $(1+x)^n$ if n is, say, a negative number or a fraction? That there is such an expansion we can easily see from a particular case. Proceed as follows:

Multiply $1-x$ by $1+x+x^2+\ldots\ldots+x^r$. We easily verify that the result is $1-x^{r+1}$.

Thus:

$$\frac{1-x^{r+1}}{1-x}=1+x+x^2+\ldots\ldots+x^r.$$

Now if x is less than 1 in value, irrespective of its sign, then the successive terms in this expression become smaller and smaller as r increases in amount. If, therefore, we make r indefinitely great $1-x^{r+1}$ ultimately becomes indistinguishable from 1, and the L.H.S. becomes $\frac{1}{1-x}$ or $(1-x)^{-1}$. On the other hand the R.H.S. becomes an unlimited succession of powers of x, the successive terms of which get smaller and smaller. Finally, therefore, we are led to the conclusion that

$(1-x)^{-1}=1+x+x^2+x^3+x^4+\ldots\ldots$ without end $\ldots\ldots$ provided x is less than 1 in amount, apart from sign.

Here, then, is an expansion, and a very simple one, that has the form of a binomial expansion in the sense that it consists of ascending powers of x. It differs from it in that it does not terminate. But there is one very significant point to be noticed.

Suppose the ordinary binomial expansion for $(1-x)^n$ were valid for $n=-1$, what would the result have been? To find this we have to insert $n=-1$ in the expression

$$1-nx+\frac{n(n-1)}{2!}x^2-\frac{n(n-1)(n-2)}{3!}x^3+\ldots$$

This gives:

$$1-(-1)\times x+\frac{(-1)(-2)}{2!}x^2$$
$$-\frac{(-1)(-2)(-3)}{3!}x^3+\ldots$$
$$=1+x+x^2+x^3+\ldots$$

which is precisely what we have found otherwise. It follows, therefore, that the Binomial Theorem can certainly be used in form at least for the case $n=-1$ provided x is less than 1.

This is in fact true generally, viz. that provided x is less than 1 in value, irrespective of sign, then

$$(1+x)^n$$
$$=1+nx+\frac{n(n-1)}{2!}x^2+\frac{n(n-1)(n-2)}{3!}x^3+\ldots$$

where n may have any value, positive or negative. It must be noticed that only in the case where n is a positive whole number will the succession of terms come to an end. It would lead us beyond the scope of this work to establish this theorem in its most general form for any value of n, but we shall indicate its truth for the case of n a negative whole number. We require to show that:

$$(1+x)^{-n}=1-nx+\frac{n(n+1)}{2!}x^2$$
$$-\frac{n(n+1)(n+2)}{3!}x^3+\ldots\ldots\ (i)$$

where n is now a positive whole number. This has been obtained by replacing n by $-n$ in the original binomial expression ; and, as we have remarked, the series of terms on the right run on indefinitely.

Let us write $S(n)$ for this expression. We have to show that in certain circumstances which we shall state,

$$S(n) = (1 + x)^{-n}.$$

Multiply each term on the R.H.S. of (i) by x, then

$$S(n)=1-nx+\frac{n(n+1)}{2\,!}x^2-\frac{n(n+1)\,(n+2)}{3\,!}x^3 + \ldots . \qquad (i')$$

$$xS(n)= x-nx^2+\frac{n(n+1)}{2!}x^3- \ldots . . \qquad (ii)$$

Adding (i′) and (ii) we have

$$(1+x)S(n)=1-(n-1)\,x+\frac{(n-1)\,n}{2!}x^2 -\frac{(n-1)\,n\,(n+1)}{3!}x^3+ \ \ldots \qquad (iii)$$

But the R.H.S. of (iii) is the same as that of (i′) provided in the latter n be replaced by $(n-1)$. Thus the R.H.S. of (iii) is necessarily represented by $S(n-1)$. Accordingly we have :

$$(1+x)\,S(n)=S\,(n-1) \ldots \ldots \ldots \qquad (iv)$$

where n is a whole positive number. We now insert in this relation (iv) successive values for n, viz. $n = 1, 2, 3, \ldots \ldots n$. This gives

$$\begin{aligned}(1+x)\,S\,(1)&=S\,(0)\\(1+x)\,S\,(2)&=S\,(1)\\(1+x)\,S\,(3)&=S\,(2)\\ &\ldots\ldots\\(1+x)\,S\,(n)&=S\,(n-1)\end{aligned}$$

If all the terms on the L.H.S. are multiplied together and equated to all the terms on the R.H.S. multiplied together we can see that

(i) there are n factors $(1+x)$ on the left, giving $(1+x)^n$

(ii) a whole succession of common factors cut out on both sides, viz.

$$S\,(1),\ S\,(2),\ S\,(3),\ \ldots\ S\,(n-1).$$

Finally, therefore, we are left with :

$$(1+x)^n\,S\,(n)=S\,(0).$$

What is $S(0)$? From (i′) by putting $n = 0$ we see that $S(0) = 1$. Hence

$$(1+x)^n\,S\,(n)=1 \text{ or } S\,(n)=(1+x)^{-n}.$$

Thus :

$$(1+x)^{-n}=S\,(n)$$
$$=1-nx+\frac{n(n+1)}{2!}x^2-\frac{n(n+1)\,(n+2)}{3!}x^3 + \ldots \ldots$$

where n is a positive whole number. If we replace n by $-n$ this means that

$$(1+x)^n=1+nx+\frac{n\,(n-1)}{2\,!}x^2 +\frac{n\,(n-1)\,(n-2)}{3\,!}x^3+\ \ldots \qquad (v)$$

is a valid expansion, where now n may be either a positive or a negative integer.

There is one further and *vital* restriction to which attention must be directed. Since the expression on the right does not terminate when n is negative it is necessary to ensure that the values of n and x are such as to give a *finite* value to the expression. It has to be arithmetically sensible and calculable. This can be ensured if, after some stage in the development, the ratio of each term to the preceding one is always *less* than 1. In this present case this requires simply that whatever the value of n, the magnitude of x must be less than 1, i.e. $+1 > x > -1$.

Example. To expand $(1+x)^{-4}$ in ascending powers of x. Here $n=-4$; inserting in (v)

$$(1+x)^{-4}=1-4x+\frac{4\times5}{2\,!}x^2-\frac{4\times5\times6}{3\,!}x^3 +\frac{4\times5\times6\times7}{4\,!}x^4- \ \ldots$$

$$\text{i.e. } \frac{1}{(1+x)^4}= 1-4x+10x^2-20x^3+35x^4- \ldots .$$

Check. We must take a value of x in the range $+1$ to -1. Take $x=0{\cdot}1$ for instance, then R.H.S.

$$=1-0{\cdot}4+0{\cdot}1-0{\cdot}02+0{\cdot}0035- \ \ldots = 0{\cdot}683$$

$$\text{L.H.S.}=\frac{1}{(1+x)^4}=\frac{1}{1{\cdot}1^4}=\frac{1}{1{\cdot}21^2}=\frac{1}{1{\cdot}4641}=0{\cdot}683$$

We notice that had we taken a larger value for x, say $x = 0{\cdot}5$, we should have required to carry the terms on the R.H.S. a great deal further before the calculation would have shown with any accuracy the value to which the whole system was approaching, or *converging*.

Example. To expand $\frac{1}{(1-x)^2}$ in ascending powers of x. Here we have to expand $(1-x)^{-2}$, so that in (v) we replace x by $-x$ and n by -2. Hence

$$\frac{1}{(1-x)^2}=1+(-2)\,(-x)+\frac{(-2)\,(-3)}{2!}(-x)^2 +\frac{(-2)\,(-3)\,(-4)}{3!}(-x)^3+\ \ldots$$
$$=1\ +\ 2x\ +\ 3x^2\ +\ 4x^3\ +\ \ldots$$

The form of the expression on the right has a simple structure and the series can be at once written down without further calculation.

The Binomial Theorem as stated in equation (v) is also valid when n is a fraction positive or negative provided again that x lies between + 1 and − 1.

The proof of this is beyond our scope here, but by simple examples it will be possible to check its truth.

Example. To expand $\sqrt{(1+x)}$, that is $(1+x)^{\frac{1}{2}}$ in ascending powers of x we insert $n=\frac{1}{2}$ in equation (v). Thus: $\sqrt{(1+x)}$

$$=(1+x)^{\frac{1}{2}}$$

$$=1+\tfrac{1}{2}x+\frac{\frac{1}{2}\,(\frac{1}{2}-1)}{2\,!}x^2+\frac{\frac{1}{2}\,(\frac{1}{2}-1)\,(\frac{1}{2}-2)}{3\,!}x^3+\,.\,.$$

$$=1+\tfrac{1}{2}x-\frac{1}{2^2.2\,!}x^2+\frac{1\,.\,3}{2^3.3\,!}x^3-\frac{1\,.\,3\,.\,5}{2^4\,.\,4\,!}x^4+\;.\;.\qquad .\;.\;.\;.\quad (vi)$$

Again the structure of the successive terms on the R.H.S. is immediately apparent.

Check. Let $x=0{\cdot}1$.

$$\sqrt{(1{\cdot}1)}=1+\frac{1}{2}\times 0{\cdot}1-\frac{1}{8}\times 0{\cdot}01+\frac{1}{16}\times 0{\cdot}001$$

$$-\frac{5}{128}\times 0{\cdot}0001+\;.\;.\;.\;.\;.\;.$$

$$=1+0{\cdot}05-0{\cdot}00125+0{\cdot}00006$$

$$-0{\cdot}000004\;.\;.\;.\;.\;.$$

$$=1{\cdot}048806\;.\;.\;.\;.$$

the last figure after the decimal point being doubtful.

Actually, direct evaluation of the square root of 1·1 gives 1·048807 . . . .

It seems, therefore, that provided the conditions attached to formula (v) are adhered to when n is not a positive integer, it may be validly applied. We may check this again in the following way. Take expression (vi) above and square it, that is, multiply it by itself. If each is $\sqrt{(1+x)}$, the result should be $1+x$. Thus:

$$\left(1+\frac{1}{2}x-\frac{1}{2^2 2\,!}x^2+\frac{1{\cdot}3}{2^3 3\,!}x^3-\;.\;.\right)\times$$

$$\left(1+\frac{1}{2}x-\frac{1}{2^2 2\,!}x^2+\frac{1{\cdot}3}{2^3 3\,!}x^3+\;.\;.\right)$$

$$=1+\left(\frac{1}{2}+\frac{1}{2}\right)x+\left(\frac{1}{2}\times\frac{1}{2}-\frac{1}{2^2 2\,!}-\frac{1}{2^2 2\,!}\right)x^2$$

$$+\left(\frac{1{\cdot}3}{2^3\,3\,!}-\frac{1}{2^3 2\,!}-\frac{1}{2^3 2\,!}+\frac{1{\cdot}3}{2^3\,3\,!}\right)x^3+\;.\;.$$

$$=1\;+\;x\;+\;0.x^2\;+\;0.x^3\;+\;.\;.\;.\;.\;.\;.$$

as required. The coefficients have been found in the usual way by direct multiplication of the two identical expressions.

Arithmetical Applications of the Binomial Theorem. We illustrate this directly by examples.

1. Required to evaluate the cube root of 65 to five places of decimals. We require $65^{\frac{1}{3}}$. The number nearest to 65 which is a perfect cube is 64, i.e. 4^3. Hence we write

$$(65)^{\frac{1}{3}}=(64+1)^{\frac{1}{3}}=(4^3+1)^{\frac{1}{3}}=\left[4^3\left(1+\frac{1}{64}\right)\right]^{\frac{1}{3}}$$

$$=4\left(1+\frac{1}{64}\right)^{\frac{1}{3}}$$

We have done this because it is legitimate to use the binomial theorem for a fractional value of n only when the x is less than 1, and the binomial form is $1+x$. We have to evaluate $\left(1+\frac{1}{64}\right)^{\frac{1}{3}}$. Accordingly

$$\left(1+\frac{1}{64}\right)^{\frac{1}{3}}=1+\frac{1}{3}\times\frac{1}{64}+\frac{\frac{1}{3}(\frac{1}{3}-1)}{2\,!}\,\frac{1}{64^2}$$

$$+\frac{\frac{1}{3}(\frac{1}{3}-1)\,(\frac{1}{3}-2)}{3\,!}\,\frac{1}{64^3}+\;.\;.\;.$$

$$=1+\frac{1}{192}-\frac{1}{9\times 64^2}+\frac{10}{162\times 64^3}\;.\;.\;.$$

and on multiplying by 4 we get

$$(65)^{\frac{1}{3}}=4+\frac{1}{48}-\frac{1}{9216}+\frac{10}{10616832}$$

The last term is of the order 10^{-6} and is in fact only 1 in the sixth decimal place. Now

$$\frac{1}{48}=0{\cdot}0208333\;.\;.\qquad \frac{1}{9216}=0{\cdot}0001085$$

Hence

$$\sqrt[3]{65}=4{\cdot}03726\;.\;.\;.$$

the last decimal place being uncertain.

2. To determine for what range of values of x it is legitimate to evaluate

$$\frac{\sqrt{(1+x)}-\sqrt{(1-x)}}{x}\text{ by using }1+\frac{1}{8}x^2$$

We note that if x lies between + 1 and −1 then:

$$\sqrt{(1+x)}=1+\tfrac{1}{2}x-\frac{1}{2^2.2\,!}x^2+\frac{1.3}{2^3.3\,!}x^3$$

$$-\frac{1.3.5}{2^4.4\,!}x^4+\frac{1.3.5.7}{2^5.5\,!}x^5\;.\;.\;.\;.$$

$$\sqrt{(1-x)}=1-\tfrac{1}{2}x-\frac{1}{2^2.2\,!}x^2-\frac{1.3}{2^3.3\,!}x^3$$

$$-\frac{1.3.5}{2^5.4\,!}x^4-\frac{1.3.5.7}{2^5.5\,!}x^5-\;.\;.\;.$$

Thus

$$\frac{\sqrt{(1+x)}-\sqrt{(1-x)}}{x}$$

$$=1+\frac{1.3}{2^2.3\,!}x^2+\frac{1.3.5.7}{2^4.5\,!}x^4+\;.\;.\;.$$

$$=1+\frac{1}{8}x^2+\frac{7}{128}x^4+\;.\;.\;.$$

It follows then that if the given function is to be indistinguishable in value from

$1+\frac{1}{8}x^2$, then $\frac{7}{128}x^4$ must be negligible. The question we have asked, therefore, is not capable of being answered unless the degree of accuracy with which $1+\frac{1}{8}x^2$ is to represent the function is stated in advance. Let us suppose, therefore, that it is required to tabulate the given function accurately to four places after the decimal point. This requires, therefore, that the term neglected, viz. $\frac{7}{128}x^4$ must be less than 5 in the next decimal place, i.e. $\frac{7}{128}x^4 < 0{\cdot}00005$

Thus $x^4 < 0{\cdot}0009$
i.e. $x^2 < 0{\cdot}03$ i.e. $-0{\cdot}17 < x < 0{\cdot}17$

and this is well within the range for which the original expansions were valid.

Check. Let $x = 0{\cdot}1$, then

$$[\sqrt{1{\cdot}1} - \sqrt{0{\cdot}9}]/0{\cdot}1 = (1{\cdot}048806 - 0{\cdot}94869)/0{\cdot}1 = 1{\cdot}0012$$

$$\text{Also } 1 + \tfrac{1}{8}x^2 = 1 + \tfrac{1}{8}(0{\cdot}1)^2 = 1 + 0{\cdot}01/8 = 1{\cdot}0012$$

both to four figures.

This example brings out yet another point to which we shall return when we are discussing the subject of limits. If we ask, what is the value of

$$[\sqrt{(1+x)} - \sqrt{(1-x)}]/x$$

when $x = 0$, it is clear that there is no immediate answer possible at all, for both the numerator and denominator of the fraction are zero, and there is no fraction or number of the type $\frac{0}{0}$

Nevertheless if a consistent answer has to be found, then it can only be the value of $1+\frac{1}{8}x^2$ when $x^2 = 0$, i.e. 1. This is a particular case of the evaluation of a limit which is itself basic to an understanding of the Differential Calculus.

EXERCISES

(1) Expand $(1-x)^{\frac{1}{4}}$, $(1+x)^{\frac{1}{4}}$ and $(1-x^2)^{\frac{1}{4}}$ in ascending powers of x.

(2) Expand $\left(1-\frac{x}{2}\right)^{\frac{1}{5}}$ in ascending powers of x as far as x^4

(3) From (2) determine the 5th root of 0·75 to 3 decimal places.

(4) Expand $(1+x)^{-2}$ by the Binomial Theorem and show that on multiplying the expansion by $1+2x+x^2$ the result is 1.

(5) Expand $\frac{1}{2}\left[\frac{1}{1+x}+\frac{1}{1-x}\right]$ in ascending powers of x, and verify that the same result is obtained by expanding $(1-x^2)^{-1}$.

Why is this so ?

(6) Show that $\left(1+\frac{1}{x}\right)^{-1} = \frac{x}{x+1}$

Hence show that if x does *not* lie in the range -1 to $+1$, then

$$\frac{x}{x+1} = 1 - \frac{1}{x} + \frac{1}{x^2} - \frac{1}{x^3} + \frac{1}{x^4} - \cdots\cdots$$

(7) Determine $\sqrt{26}$ to 3 decimal places.

(8) Find for what range of x it is legitimate to use $2 - \frac{2x^4}{9}$ to calculate the value of $\sqrt[3]{(1+x^2)} + \sqrt[3]{(1-x^2)}$ to four decimal places.

Answers to Exercises in Lesson 23

(1) *See* Fig. 122.

(2) $x = 4{\cdot}19$, $x = -1{\cdot}19$.

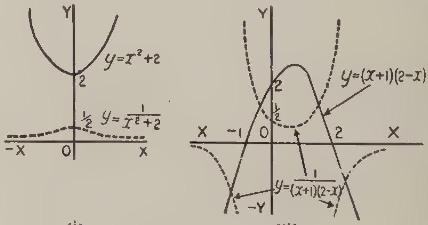
(3) Minimum value is $2\frac{3}{4}$ when $x = 1\frac{1}{2}$.

(5) *See* Fig. 123 ((i)—(v)).

(6) *See* Fig. 124 (i and ii).

(7) (i) 2·84. (ii) − 2·41, − 1·15, 3·58.

(8) 2·2, more accurately 2·175.



(i) (ii)

Fig. 124

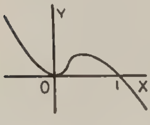
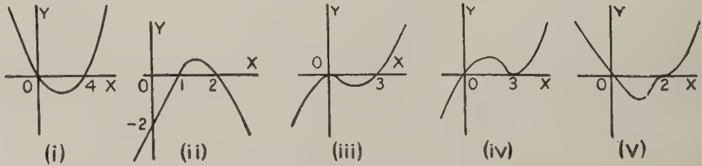


Fig. 122



(i) (ii) (iii) (iv) (v)

Fig. 123

***STANDARD CURVES AND GRAPHICAL SOLUTIONS.** Figs. 122-124. Answers to Exercises 1, 5 and 6 in page 268 in equations for standard curves and graphical solutions of algebraic equations.*

LESSON 25

Elementary Statistics

When it is stated that a town A has more sunshine than a town B, we do not mean that on every day of the year A is sunnier than B. If we say that the boys or girls in one class are older than those in another we do not mean that every individual in the one is older than every individual in the other. In both cases we are stating something about the group ; in the one case we are referring to the total amount of sunshine or the *average* amount of sunshine in these towns, and in the other case to the total ages or perhaps simply the average age of the class of boys or girls. We shall see in a moment what the average really means, why we use it at all, and how much meaning it has for us.

These illustrations have been mentioned in order to bring out the fact that while in ordinary arithmetic we deal with things described by a single number, in the field of *statistics* we are concerned with measurements about a group and therefore we have to deal with a group of numbers. In the case of a class of children, if we wish to consider the 'age' of the class, we have to take into account the ages of all the members of the class.

The Average of a Set of Numbers. Suppose a class of ten boys shows the following ages, in years :

9, 12, 10, 9, 11, 10, 12, 11, 10, 12

The sum total of the ages is 106. There are in all 10 boys in the class. The average age is 106/10 = 10·6 years.

More generally, if

$$a_1, a_2, a_3, \dots a_n$$

be n numbers, the *mean* or *average* value is defined as

$$(a_1 + a_2 + a_3 + \dots + a_n)/n.$$

The average of a set is usually written by placing a horizontal bar above the typical letter. For instance in this case the above value would be written as $\bar{a}$.

Is the average of a set of numbers a good and sufficient description of that set ?

The first point to notice about an average is that it lies more or less centrally in the set. If we have two numbers, for instance 20 and 30, the average is $\frac{1}{2}(20+30) = 25$, which lies exactly midway between 20 and 30. If we have three numbers, say 11, 12, 16, the average is 13, which more or less lies centrally within the set of numbers. Let us make this statement more exact.

Definition. The *deviations* of a set of numbers, say $x_1, x_2, \dots x_n$ from their mean or average are defined as the differences of each number of the set from the mean value of the set, viz. $\bar{x}$. Thus :

$$\bar{x} = (x_1 + x_2 + \dots + x_n)/n \qquad (i)$$

and the successive deviations are

$$x_1 - \bar{x},\ x_2 - \bar{x}, \dots x_n - \bar{x} \qquad (ii)$$

We shall now show that the value of $\bar{x}$ is such that the sum of the differences of all the numbers above it from the average is equal to the sum of the differences of all the numbers below it.

Example. 4, 6, 9, 9, 8, 6, 4, 5, 5, 4.

Average $\bar{x} = (4+6+9+9+8+6+4+5+5+4)/10 = 6$

Deviations from the average :

$4-6=-2$, $6-6=0$, $9-6=3$, $9-6=3$, $8-6=2$, $6-6=0$, $4-6=-2$, $5-6=-1$, $5-6=-1$, $4-6=-2$.

The sum of the positive deviations is $3+3+2=8$.

The sum of the negative deviations is $-2-2-1-1-2=-8$.

It is therefore in this sense that we say that the average lies centrally among a set of numbers.

Because of this it will very frequently be possible to refer to a set of experimental measurements of the same physical phenomenon by the average value obtained. For example, when we say that under certain circumstances the speed of sound is 1,190 ft. per sec., we mean that a number of measurements have been taken to obtain this result.

These differ from each other since the circumstances associated with each reading vary from one occasion to the next. Thus the measurements may range from 1,200 ft. per sec. to 1,180 ft. per sec. The value 1,190 is found by taking the average or mean of all the readings, and the deviations from the average are thought of as the experimental errors.

Can we sav that the average is a sufficient description of a group of numbers ? Take a simple case :

The average of 10 and 90 is 50.
The average of 49 and 51 is 50.

Here are two pairs of numbers that differ very much from each other. The first pair has a *range* of 80, viz. 90 − 10, the second a range of 2, viz. 51 − 49, and yet they have the same average.

How are we to bring out this spread of the numbers? It is clear that the average itself does not succeed in doing so. We could, of course, besides the average, take the range, i.e., the difference between the largest and the smallest of the set, but as we shall see even that is not satisfactory. For example, consider the two sets

(i) 1·0, 1·0, 1·0, 1·0, 1·4, 1·4, 1·4, 1·4
Average 1·2
Range 0·4

(ii) 1·0, 1·2, 1·2, 1·2, 1·2, 1·2, 1·2, 1·4
Average 1·2
Range 0·4

Here are two sets that differ very definitely in character, although they have the same average and the same range. In the first case the numbers occur at the two extremes, in the second case they are mainly bunched about the average. If they were intended to be readings of the same physical effect, we could not avoid saying that the second set is better since most of the readings actually coincide with the average.

The point to bear in mind is that we are trying to find a method of describing the collection or group of numbers. The average is valuable but it is not sufficient. The range may also be valuable but it may be misleading. We return therefore to the deviations from the average. In these cases they are

(i) −0·2, −0·2, −0·2, −0·2, 0·2, 0·2, 0·2, 0·2
(ii) −0·2, 0, 0, 0, 0, 0, 0, 0·2

Although the sum of the deviations is zero in both cases, the actual numbers are larger in the first case than in the second case. What we require is an over-all measure of the size of these deviations irrespective of their sign for these are assuredly associated with their spread and the way in which the numbers are heaped up at the ends of the range in the first case, and at the middle of the range in the second case. For this purpose therefore we define a new quantity, the *Standard Deviation*, usually written σ (Greek *sigma*).

The Standard Deviation is the square root of the average value of the squares of the deviations.

For example, in the above two cases, the squares of the deviations are:

(i) 0·04, 0·04, 0·04, 0·04, 0·04, 0·04, 0·04, 0·04
(ii) 0·04, 0, 0, 0, 0, 0, 0, 0·04

The average value of these numbers in each case is

(i) 0·04 (ii) 0·01.

The standard deviation is the square root of these numbers. Thus

(i) $\sigma = 0{\cdot}2$ (ii) $\sigma = 0{\cdot}1$.

Thus the standard deviation in the first case is twice that in the second, corresponding to the fact that in the first case the numbers were heaped up at the ends of the range, and in the second case that they were crowded together in the centre.

Generally, therefore, if $x_1, x_2, x_3, \ldots x_n$ is a set of n numbers whose average is $\bar{x}$, then the squares of their deviations from the average is

$$(x_1 - \bar{x})^2,\ (x_2 - \bar{x})^2,\ \ldots (x_n - \bar{x})^2.$$

The average value of these numbers is

$$\frac{1}{n}\left[(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + \ldots + (x_n - \bar{x})^2\right],$$

and this is the square of the standard deviation. Thus

$$\sigma^2 = \frac{1}{n}\left[(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + \ldots + (x_n - \bar{x})^2\right] \quad \ldots\ldots (iii)$$

Suppose we had not taken the average value $\bar{x}$ from which to measure the deviations but another number, say M. We would, of course, not have found σ but a corresponding value, say S. Let us examine S.

$$\begin{aligned}
S^2 &= \frac{1}{n}\left[(x_1 - M)^2 + (x_2 - M)^2 + \ldots . (x_n - M)^2\right] \\
&= \frac{1}{n}\left[(x_1 - \bar{x} + \bar{x} - M)^2 + \ldots . (x_n - \bar{x} + \bar{x} - M)^2\right] \\
&= \frac{1}{n}\Big[(x_1 - x)^2 + 2(\bar{x} - M)(x_1 - \bar{x}) + (\bar{x} - M)^2 \\
&\quad + (x_2 - \bar{x})^2 + 2(\bar{x} - M)(x_2 - \bar{x}) + (\bar{x} - M)^2 \\
&\quad + \ldots\ldots\ldots \\
&\quad + (x_n - \bar{x})^2 + 2(\bar{x} - M)(x_2 - \bar{x}) + (\bar{x} - M)^2\Big]
\end{aligned}$$

Now the sum of the first terms in each row is the sum of the squares required for the calculation of σ^2.

Again every second term in each row has a factor $2(\bar{x} - M)$. If we add all these second terms, therefore, we should have $2(\bar{x} - M)$ multiplied by

$$\begin{aligned}
&(x_1 - \bar{x}) + (x_2 - \bar{x}) + \ldots . + (x_n - \bar{x}) \\
&= x_1 + x_2 + \ldots\ldots x_n - n\bar{x} \\
&= n\bar{x} - n\bar{x} = 0.
\end{aligned}$$

It follows that the sum of the second terms contributes nothing to S^2.

Every third term is the same, viz. $(\bar{x} - M)^2$. Thus:

$$S^2 = \frac{1}{n}\left[n\sigma^2 + n(\bar{x} - M)^2\right]$$

or $S^2 = \sigma^2 + (\bar{x} - M)^2$ or $\sigma^2 = S^2 - (\bar{x} - M)^2$ *(iv)*

This shows at once that if we take the wrong mean the value of S^2 found in this way would always be greater than the actual standard deviation. When M is chosen to be the mean, however, S^2 reaches its least value, viz., σ^2. Stated otherwise, the sum of the squares of the deviations is a minimum when the number from which the deviations are measured is chosen equal to the mean of the readings. This then is the property that links together the two characteristic numbers we have chosen, on other grounds, to represent the group.

The relation (iv) provides a convenient method of evaluating the standard deviation in most cases. For a set of numbers do not in general give a round or simple value for the average, so that if we use the direct definition of σ given by (iii), the calculation of σ may be very heavy. On the other hand if we use (iv), and calculate S from a false but convenient 'mean,' M, the labour is enormously reduced.

Example. To find the mean and the standard deviation of the following set of numbers:

10, 9, 11, 14, 12, 12, 9, 10.

$$\text{Average} = \overline{x}$$
$$= \frac{1}{8}\,[10+9+11+14+12+12+9+10]$$
$$= \frac{1}{8}\times 87 = 10\tfrac{7}{8}.$$

Instead of the true mean 10·875, let us choose 10, a false mean. Then the deviations are

0, −1, 1, 4, 2, 2, −1, 0

Thus:

$$S^2 = \frac{1}{8}\,[0^2+1^2+1^2+4^2+2^2+2+2^2+1^2+0^2]$$
$$= \frac{1}{8}\times 31$$
$$\sigma^2 = S^2-(\overline{x}-M)^2 = \frac{31}{8}-\left(10\tfrac{7}{8}-10\right)^2 = \frac{31}{8}-\frac{49}{64}$$
$$= \frac{199}{4} \text{ i.e. } \sigma = 1{\cdot}76$$

It is clear that had we obtained each deviation from the true mean, viz. $10\frac{7}{8}$ = 10·875 every term would have involved decimals, and the calculation of their squares would have been much more laborious.

Studying the Frequency. The two measures we have chosen to represent a group of numbers suffice to describe certain aspects. In themselves, however, they do not give us a picture of a set of readings *as a group*. This can best be seen by drawing a *frequency* diagram. We illustrate with a particular example.

Here are the marks of 16 candidates for an examination:

18, 24, 24, 25, 34, 45, 50, 54, 54. 55. 56. 70, 75, 77, 78, 88.

We divide them into equal ranges of marks, say, those that fall between 1–20, 21–40, 41–60, 61–80, 81–100.

Hence we have the following table:

Mark Range	1–20	21–40	41–60	61–80	81–100
Marks	18	24, 24 25, 34	45, 50 54, 54 55, 56	70, 75 77, 78	88
Number of Candidates in each range	1	4	6	4	1

By this means we have classified the candidates into five groups, the numbers 1, 4, 6, 4, 1 telling us how many of the candidates fall into each group. These latter numbers therefore are called the frequencies.

To illustrate this by a diagram we proceed as in Fig. 125.

The horizontal axis is divided up into the equal ranges, and at the *centre* of each range a perpendicular line is erected equal in length to the frequency of the occurrence of candidates in that range.

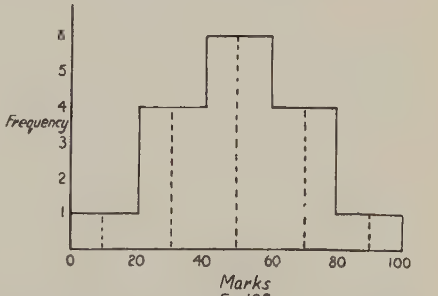


Fig.125

FREQUENCY DIAGRAM. Fig. 125. This histogram shows the mean and standard deviation for the marks obtained by sixteen candidates.

When a horizontal line is drawn across the range at the top of each ordinate, the block diagram so obtained is called a *histogram*.

The average mark is then estimated by multiplying the central value of each range by the number falling in this range and dividing by the total number of candidates. This is equivalent to assuming that all the candidates that fall in that range have the same mark. While, therefore, the method gives us a picture of the performance of the whole group it does so at the expense of slurring over the individual performances of the candidates.

The mid-value of the ranges are

$10\frac{1}{2}$, $30\frac{1}{2}$, $50\frac{1}{2}$, $70\frac{1}{2}$, $90\frac{1}{2}$.

These have to be multiplied by

1, 4, 6 4, 1

respectively, the results added and divided by 16.

Thus Average =

$$\frac{1\times 10\frac{1}{2}+4\times 30\frac{1}{2}+6\times 50\frac{1}{2}+4\times 70\frac{1}{2}+1\times 90\frac{1}{2}}{16}$$

$$=\frac{1}{16}[10\tfrac{1}{2}+122+303+282+90\tfrac{1}{2}]$$

$$=50{\cdot}5.$$

The standard deviation can be calculated directly by taking this average, rather than a false value since by that means we avoid the occurrence of fractions.

Deviations from the mean and the frequencies with which they occur are as follow:

Deviations from mean	$10{\cdot}5-50{\cdot}5 = -40$	$30{\cdot}5-50{\cdot}5 = -20$	$50{\cdot}5-50{\cdot}5 = 0$
Frequencies	1	4	6
Deviations from mean	$70{\cdot}5-50{\cdot}5 = 20$	$90{\cdot}5-50{\cdot}5 = 40$	
Frequencies	4	1	

Hence

$$\sigma^2 = \frac{1\times(40)^2+4(20)^2+6(0)^2+4\times(20)^2+1\times(40)^2}{16}$$

$$=\frac{1600+1600+1600+1600}{16}$$

$= 400$. Hence $\sigma = 20$.

In what sense can we now say that $\sigma = 20$ gives a measure of the spread or dispersion of the marks about the mean viz. 50·5 ? Let us reply by asking a counter-question. How many candidates fall within a range of (±) 20 of the average ? This ranges from $50{\cdot}5 - 20 = 30{\cdot}5$ to $50{\cdot}5 + 20 = 70{\cdot}5$. The number 30·5 falls exactly mid-way in the interval 21–40 within which 4 candidates fall. We take 2 of these therefore as falling within the band $\pm\sigma$ about the average. In addition 6 fall in the range 41–60 and for the same reason as before we must add 2 from the range 61–80 since 70·5 falls midway. Thus altogether $2+6+2 = 10$ candidates fall within the band $\pm\sigma$ about the average—or a proportion of 10/16 of the total. Thus for this set of candidates 62·5 per cent of the candidates fall in the range $\pm\sigma$. If in this type of examination this batch of 16 candidates is typical we have now a measure of what to expect in future cases.

In fact by keeping a record of the performances of candidates in the past we can draw a histogram and obtain a measure σ and an average. We can state what proportion is to be expected to fall within the range $\pm\sigma$ for future batches and hence we can determine whether such a batch is a normal collection or not.

Application to Engineering. This method of analysis is now of great importance in relation to standardized engineering production. In place of candidates and their marks we have engineering material that is being produced to standardized size. For a whole variety of reasons the individual items differ slightly among themselves. The average should be the specified size if the system is working correctly and stably. The value of σ can be calculated from the material which has been produced in the past. Later batches can then be tested to determine whether they are consistent with this. It is not our purpose here to enter into this field of engineering statistics which goes by the name of *Quality Control* as that has now become a separate field of study and of engineering practice. It must suffice to give this indication of the lines along which the analysis would proceed.

EXERCISES

(1) Find the mean of each of the two following sets of numbers :

(i) 4·2, 4·6, 5·9, 7·3, 8·5 ;

(ii) 4·2, 4·6 (twice), 5·9, 7·3 (five times), 8·5 (eight times). Explain why the mean of (ii) is much larger than the mean of (i).

(2) 30 engines were examined for defects. with the following results :

1 engine had 0 defect.
4 engines had 1 defect.
10 engines had 2 defects.
8 engines had 3 defects.
5 engines had 4 defects.
2 engines had 5 defects.

(i) How many defects were there in all ?
(ii) What was the average number of defects per engine ?

(3) The lengths of 30 rods are given in inches as follows :

28	18	24	27	20	17	23	34	26	19
13	16	29	24	23	25	22	26	11	24
20	19	25	25	23	24	21	25	26	24

Find the average length of rod. Group the measurements in the ranges 10—15, 15—20, 20—25, 25—30, 30—35 inches and draw the histogram.

(4) The ages (in years) of a group of 6 boys are 12, 16, 14, 17, 15, 16. Find the mean and standard deviation of their ages directly. Calculate the average of the squares of the deviations of each age from 12, 13, 14, 15, 16, 17 in turn and show that the average of these squared deviations in each case is greater than that taken from the mean.

Show that the true standard deviation may be obtained by using relation (4) by calculating it in turn from false means of 12, 17, 14.

Answers to Exercises in Lesson 24

(1) (i) $1-\frac{1}{4}x-\frac{3}{32}x^2-\frac{7}{128}x^3-\frac{77}{2048}x^4-\dots$

(ii) $1+\frac{1}{4}x-\frac{3}{32}x^2+\frac{7}{128}x^3-\frac{77}{2048}x^4+\dots$

(iii) $1-\frac{1}{4}x^2-\frac{3}{32}x^4-\frac{7}{128}x^6-\frac{77}{2048}x^8-\dots$

(2) $1-\frac{1}{10}x-\frac{1}{50}x^2-\frac{3}{500}x^3-\frac{33}{20{,}000}x^4-\dots$

(3) 0·944. (7) 5·099. (8) $-0{\cdot}53<x<0{\cdot}53$.

LESSON 26

The Trigonometry of the Triangle

We now propose to link up the subjects of geometry and trigonometry much more closely than in any of the previous work. It is true, of course, that we defined the trigonometrical ratios by reference to a right-angled triangle but we will now obtain relations between the sides and angles of *any* triangle.

It is convenient to adopt a standard notation when dealing with this part of the work. We denote the magnitude of the angles of any triangle ABC by the letters A, B and C, and the lengths of the sides opposite to these angles by a, b, c respectively. The radius of the inscribed circle of the triangle ABC is represented by r, while R denotes the radius of the circumscribed circle of the triangle ABC. The area of this triangle is conveniently represented by the symbol $\triangle$.

The 'Sine Rule.' This states that for any triangle ABC,

$$\frac{a}{\sin A}=\frac{b}{\sin B}=\frac{c}{\sin C}=2R$$

Consider Fig. 126 (a). Here we have drawn any triangle ABC and constructed a perpendicular AD on to the side BC. Since this perpendicular might fall on the base BC produced we must consider whether this fact will affect our proof. Thus we need to consider the two possible cases which may arise, indicated by Figs. 126, (a) and (b). In (a) it is clear that since both ADC and ADB are right-angled triangles, then AD $= c \sin B$ or alternatively, $b \sin C$. In (b), from the triangle ABD, AD $= c \sin B$ as before, but a difference apparently occurs in the triangle ADC. Here AD $= b \sin \angle ACD = b \sin (180° - C)$, but since $\sin (180°-c) = \sin C$ we have exactly the same relation in both cases, namely

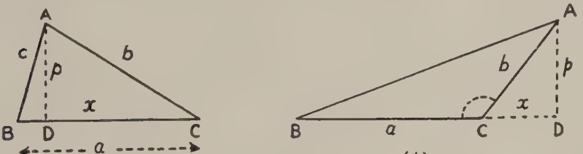
$$b \sin C = c \sin B$$

i.e. $$\frac{b}{\sin B}=\frac{c}{\sin C}$$

Similarly, we may draw perpendiculars from either of the two other vertices, when either case (a) or (b) must apply, so that we obtain a general relation, true of all triangles, that

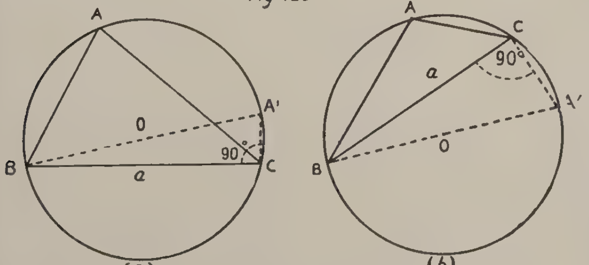
$$\frac{a}{\sin A}=\frac{b}{\sin B}=\frac{c}{\sin C}$$

To prove that either of these ratios is equal to 2R, consider Figs. 127 (a) and (b). We have drawn two triangles ABC, together with their circumscribed circles, the difference in the two cases being that in (b) ABC lies wholly in a semicircle. In each case, join B to the centre of the circle, and produce to



(a) (b)

Fig 126



(a) (b)

Fig. 127

Figs. 126 (a) and (b). The sine rule applied to any triangle A B C. Figs. 127 (a) and (b) demonstrate that either of the ratios a/sin A= b/sin B=c/sin C is equal to 2R (radius of the circumscribed circle of the triangle A B C).

meet the circumference in A′. Join CA′. We now need to use some of the geometrical facts obtained in Lesson 6; first, that the angle in a semicircle is a right angle. Thus in each case the

$$a = \text{A}'\text{B} \cos \angle \text{A}'\text{BC}$$

$$\text{i.e.} \quad a = 2\text{R} \cos \angle \text{A}'\text{BC} \quad \ldots\ldots \quad (i)$$

since A′B is a diameter of the circumscribed circle. Secondly, in both cases $\angle \text{BA}'\text{C} = 90° - \angle \text{A}'\text{BC}$ i.e. $\cos \angle \text{A}'\text{BC} = \sin \angle \text{BA}'\text{C}$. Considering (a) only, the angle BA′C = A since by a geometrical theorem the angles in the same segment of a circle, standing on the same chord, are equal. Thus as regards Fig. 127 (a), relation (i) becomes

$$\begin{aligned} a &= 2\text{R} \sin \angle \text{BA}'\text{C} \\ &= 2\text{R} \sin \text{A}. \end{aligned}$$

For Fig. 127 (b), ∠BA′C (i.e. A′) = 180° − A, since the opposite angles of a cyclic quadrilateral together add up to 180°, and therefore in this case relation (i) becomes

$$a = 2\text{R} \sin (180° - \text{A})\,;$$

but since

$$\sin (180° - \text{A}) = \sin \text{A},$$

we have also in this case that

$$a = 2\text{R} \sin \text{A},$$

so that in *all* cases

$$\frac{a}{\sin \text{A}} = 2\text{R}.$$

There is another important theorem which has no particular name but states that there are three relations between the sides and angles of any triangle of the form

$$a = b \cos \text{C} + c \cos \text{B}.$$

This may be proved by again considering Figs. 126 (a) and (b).

For (a)

$$\begin{aligned} a &= \text{BD} + \text{CD} \\ &= c \cos \text{B} + b \cos \text{C} \end{aligned}$$

and for (b),

$$\begin{aligned} a &= \text{BD} - \text{CD} \\ &= c \cos \text{B} - b \cos \angle \text{ACD} \\ &= c \cos \text{B} - b \cos (180° - c) \\ &= c \cos \text{B} + b \cos \text{C} \end{aligned}$$

because $\cos (180° - \text{C}) = -\cos \text{C}$.

By drawing perpendiculars from the other two vertices we obtain the other two relations of this type, which are

$$b = a \cos \text{C} + c \cos \text{A}$$

$$\text{and} \quad c = a \cos \text{B} + b \cos \text{A}.$$

The 'Cosine Rule.' This is the name given to three relations of the form

$$c^2 = a^2 + b^2 - 2ab \cos \text{C},$$

which may be proved by the application of the Theorem of Pythagoras. Refer again to Figs. 126 (a) and (b), and let AD be denoted by p and CD by x. Then for (a),

$$\begin{aligned} c^2 &= \text{AD}^2 + \text{BD}^2 \\ &= p^2 + (a - x)^2 \\ &= p^2 + a^2 - 2ax + x^2 \\ &= b^2 + a^2 - 2ax \quad \ldots\ldots\ldots \quad (ii) \end{aligned}$$

because $p^2 + x^2 = b^2$. Now $x = b \cos \text{C}$, so that (ii) becomes

$$c^2 = b^2 + a^2 - 2ab \cos \text{C}.$$

For the case where C is obtuse, Fig. 126 (b), we have

$$\begin{aligned} c^2 &= p^2 + (a + x)^2 \\ &= p^2 + a^2 + 2ax + x^2 \\ &= b^2 + a^2 + 2ax \quad \ldots\ldots\ldots \quad (iii) \end{aligned}$$

as before; but here

$$\begin{aligned} x &= b \cos \angle \text{ACD} \\ \text{i.e.} \quad x &= b \cos (180° - \text{C}) \\ &= -b \cos \text{C}, \text{ so that (iii) becomes} \\ c^2 &= b^2 + a^2 - 2ab \cos \text{C} \quad \ldots\ldots \quad (iv) \end{aligned}$$

proving the result generally. The two other relations of this type are

$$a^2 = b^2 + c^2 - 2bc \cos \text{A}$$

$$\text{and} \quad b^2 = c^2 + a^2 - 2ac \cos \text{B},$$

and it should be noticed that they provide the means of obtaining the cosine of each of the angles of *any* triangle in terms of the sides only, for (iv) may be written

$$\cos \text{C} = \frac{b^2 + a^2 - c^2}{2\,ab} \quad \ldots\ldots\ldots\ldots \quad (v)$$

Example. Find the largest angle of the triangle whose sides are 6, 7, 8 ins.

The largest angle is that opposite the longest side; in this case it is the angle opposite to the side of length 8 ins. Thus

$$8^2 = 6^2 + 7^2 - 2.\ 6.\ 7 \cos \text{C}$$

(if we take $c = 8$), so that, re-arranging,

$$\begin{aligned} \cos \text{C} &= \frac{6^2 + 7^2 - 8^2}{2.\ 6.\ 7} \\ &= \frac{21}{84} = \tfrac{1}{4} \end{aligned}$$

and, from tables,

$$\text{C} = 75°\ 31'.$$

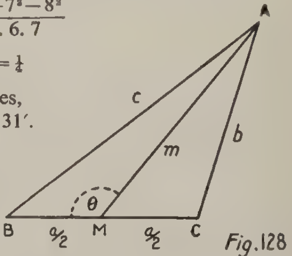


Fig. 128. Cosine rule applied to two triangles.

Example. Prove that in any triangle ABC, if m represents the median drawn from A on to BC, then $4m^2 = 2b^2 + 2c^2 - a^2$.

In Fig. 128 ABC is the triangle and AM the median. Let $\angle \text{AMB} = \theta$, so that applying the cosine rule to the triangle AMB,

$$c^2 = m^2 + \frac{a^2}{4} - 2\,.\,m\,.\,\frac{a}{2} \cos \theta \quad \ldots\ldots \quad (vi)$$

Also, by applying the cosine rule to the triangle AMC, we obtain

$$b^2 = m^2+\frac{a^2}{4}-2\,.\,\frac{a}{2}\,.\,m\cos(180^\circ-\theta)$$

$$= m^2+\frac{a^2}{4}+2\,.\,\frac{a}{2}\,.\,m\cos\theta \quad . \; . \; . \quad (vii)$$

Adding relations (vi) and (vii)

$$b^2+c^2 = 2m^2+\tfrac{1}{2}a^2$$

i.e. $4m^2 = 2b^2+2c^2-a^2$.

The cosine rule has enabled us to write the cosine of any angle of a triangle in terms of the sides alone, and therefore, using the fundamental identity $\sin^2 A+\cos^2 A = 1$, we may obtain an expression for the sine of any angle of a triangle in terms of the sides only. Thus:

$$\cos A = \frac{b^2+c^2-a^2}{2bc}$$

therefore

$$\sin^2 A = 1-\cos^2 A$$

$$= 1-\left(\frac{b^2+c^2-a^2}{2bc}\right)^2$$

We may simplify the expression on the R.H.S. by noticing that it is the difference of two squares, and so we may write

$$\sin^2 A = \left(1+\frac{b^2+c^2-a^2}{2bc}\right)\left(1-\frac{b^2+c^2-a^2}{2bc}\right)$$

$$= \frac{1}{4b^2c^2}\,(2bc+b^2+c^2-a^2)\,(2bc-b^2-c^2+a^2)$$

by putting each term on the R.H.S. over its common denominator. We may further simplify the R.H.S. thus:

$$\sin^2 A = \frac{1}{4b^2c^2}\,(b^2+2bc+c^2-a^2)(a^2-(b^2-2bc+c^2))$$

$$= \frac{1}{4b^2c^2}\,[(b+c)^2-a^2]\,[a^2-(b-c)^2],$$

and now each factor on the R.H.S. is itself the difference of two squares, i.e.

$$\sin^2 A = \frac{1}{4b^2c^2}\,(b+c+a)\,(b+c-a)\times (a-b+c)\,(a+b-c) \quad . \; . \; . \; . \; . \quad (viii)$$

These factors on the R.H.S. are of common occurrence in work of this nature and it is convenient to write $2s = a+b+c$. The R.H.S. may then be written much more simply in terms of s, for

$b+c-a = b+c+a-2a$, i.e. $2s-2a$,
similarly $a-b+c = a+b+c-2b = 2s-2b$

and so (viii) may be written

$$\sin^2 A = \frac{1}{4b^2c^2}\quad 2s\,.\,(2s-2a)\,(2s-2b)\,(2s-2c)$$

$$= \frac{4}{b^2c^2}\,s\,(s-a)\,(s-b)\,(s-c)$$

i.e.

$$\sin A = \frac{2}{bc}\sqrt{(s\,(s-a)\,(s-b)\,(s-c))} \quad . \; . \; . \; . \quad (ix)$$

The Area of a Triangle. Refer again to Figs. 126 (a) and (b). In both cases the area of the triangle ABC $= \frac{1}{2}$ AD. BC, and since AD was shown to be equal to $b \sin C$ in both cases, and BC $= a$, we have

$$\triangle = \tfrac{1}{2}a\,.\,b\sin C.$$

By analogy with relation (ix)

$$\sin C = \frac{2}{ab}\sqrt{(s(s-a)\,(s-b)\,(s-c))}$$

and therefore the area of the triangle ABC is given by

$$\triangle = \tfrac{1}{2}ab\,.\,\sin C$$

$$= \sqrt{(s(s-a)\,(s-b)\,(s-c))} \quad . \; . \; . \; . \quad (x)$$

From this relation we may obtain the area of *any* triangle, knowing the lengths of the three sides.

The Radius of the Inscribed Circle of a Triangle. Let ABC (Fig. 129) be any triangle and D, E, F the points where the inscribed circle touches the sides. Join A, B and C to I, the centre of the inscribed circle. Then ID = IE = IF = r and each of these radii is perpendicular to the sides of the triangle, so that

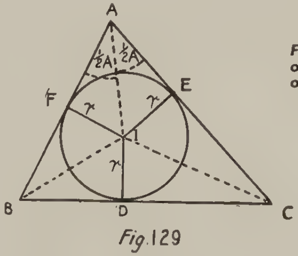


Fig. 129. Radius of inscribed circle of triangle A B C.

$$\text{area}\ \triangle\,\text{ABC} = \text{area}\ \triangle\,\text{AIB}+\text{area}\ \triangle\text{BIC} + \text{area}\ \triangle\text{CIA}$$

$$= \tfrac{1}{2}r\,.\,\text{AB}+\tfrac{1}{2}r\,.\,\text{BC}+\tfrac{1}{2}r\,.\,\text{AC}$$

$$= \tfrac{1}{2}r\,(\text{AB}+\text{BC}+\text{AC})$$

$$= \tfrac{1}{2}r\,(a+b+c)$$

$$= \tfrac{1}{2}r\,.\,2s$$

$$= rs$$

so that $\triangle = rs$

or $r = \dfrac{\triangle}{s}$.

Summarizing, therefore, we have the following group of formulae for any triangle:

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c} = \frac{1}{2R}$$

$$= \frac{2\triangle}{abc} = \frac{2rs}{abc} = \frac{2}{abc}\sqrt{s(s-a)\,(s-b)\,(s-c)}$$

$$a^2 = b^2+c^2-2bc\cos A$$
$$b^2 = c^2+a^2-2ca\cos B$$
$$c^2 = a^2+b^2-2ab\cos C$$

The 'Half-Angle' Formulae. From the same diagram (Fig. 129) we obtain an important relation concerning tan ½A. The triangles AIF, AIE are congruent since AF = AE (tangents from an external point to a circle are equal) so that

$$\angle FAI = \tfrac{1}{2}A \quad .$$

$$\text{Thus } \tan \tfrac{1}{2}A = \frac{r}{AF} \quad \ldots\ldots\ldots\ldots \quad (xi)$$

and we may obtain AF in terms of s. From the geometrical theorem we have just quoted, AE = AF, CE = CD, BF = BD and therefore

$$\begin{aligned} 2s &= a+b+c \\ &= a+(CE+AE)+(BF+AF) \\ &= a+CE+BF+2AF \\ &= a+CD+BD+2AF \\ &= 2a+2AF \end{aligned}$$

$$\text{i.e. } AF = s-a$$

so that (ii) becomes

$$\tan \tfrac{1}{2}A = \frac{r}{s-a}$$

and since

$$r = \frac{\Delta}{s} \text{ we have}$$

$$\begin{aligned} \tan \tfrac{1}{2}A &= \frac{\Delta}{s(s-a)} \\ &= \frac{\sqrt{s(s-a)(s-b)(s-c)}}{s(s-a)} \\ &= \sqrt{\frac{(s-b)(s-c)}{s(s-a)}} \quad \ldots\ldots\ldots \quad (xii) \end{aligned}$$

From this relation for tan ½A we may deduce the corresponding relations for cos ½A and sin ½A.

$$\text{Now} \qquad \sec^2 \tfrac{1}{2}A = 1+\tan^2 \tfrac{1}{2}A$$

$$\begin{aligned} \therefore \qquad \sec^2 \tfrac{1}{2}A &= 1+\frac{(s-b)(s-c)}{s(s-a)} \\ &= \frac{s(s-a)+(s-b)(s-c)}{s(s-a)} \\ &= \frac{2s^2-sa-sb-sc+bc}{s(s-a)} \\ &= \frac{2s^2-s(a+b+c)+bc}{s(s-a)} \\ &= \frac{2s^2-s\,.\,2s+bc}{s(s-a)} \\ &= \frac{bc}{s(s-a)} \end{aligned}$$

$$\begin{aligned} \text{i.e.} \qquad \cos^2 \tfrac{1}{2}A &= \frac{1}{\sec^2 \tfrac{1}{2}A} \\ &= \frac{s(s-a)}{bc} \end{aligned}$$

$$\text{or} \qquad \cos \tfrac{1}{2}A = \sqrt{\frac{s(s-a)}{bc}}$$

$$\text{Also, since } \tan \tfrac{1}{2}A = \frac{\sin \tfrac{1}{2}A}{\cos \tfrac{1}{2}A}$$

$$\begin{aligned} \text{we have} \qquad \sin \tfrac{1}{2}A &= \cos \tfrac{1}{2}A \,.\, \tan \tfrac{1}{2}A \\ &= \sqrt{\frac{s(s-a)}{bc}}\,.\,\sqrt{\frac{(s-b)(s-c)}{s(s-a)}} \\ &= \sqrt{\frac{(s-b)(s-c)}{bc}} \end{aligned}$$

In each case there are corresponding expressions for the sine, cosine and tangent of ½B and ½C.

EXERCISES

(1) Find the angles A and B and the side c of the triangle for which $a = 3''$, $b = 5''$, $C = 60°$.

(2) Show that there are two triangles having $b = 3$, $c = 4$, $B = 40°$ and find the angle A in each case.

(3) Show that $b = 5$, $c = 20$, $B = 40°$ cannot form a triangle.

(4) In a triangle $\sin^2 C = \sin^2 A+\sin^2 B$. Prove that the triangle is right-angled.

(5) If l is the length of a diagonal of a parallelogram which makes angles A, B with the sides, show that the lengths of the sides are $l \sin A/\sin (A+B)$ and $l \sin B/\sin (A+B)$.

(6) Given $c = 10$, $a = 12$, $B = 35°$, find the length of the median which bisects BC.

(7) In a triangle ABC prove that

$$(c-a \cos B) \tan A = a \sin B.$$

(8) The lengths of the sides of a cyclic quadrilateral are represented by a, b, c, d and the angle between a and b is θ. Draw the diagonal opposite to θ and express its length by applying the cosine rule to each of the triangles so formed. From these two expressions prove that

$$\cos \theta = \frac{a^2+b^2-c^2-d^2}{2\,(ab+cd)}$$

(9) In a triangle $a = 13$, $b = 14$, $c = 15$ ft. Find R, r, Δ.

(10) A tower, of height T, standing on a hill sloping at an inclination α to the horizontal, throws a shadow (of length S) directly downhill. Show that the inclination θ of the sun's rays to the hillside is given by

$$\cot \theta = \tan \alpha + \frac{S}{T \cos \alpha}$$

If T = 100 ft., $\alpha = 10°$ and S = 120 ft., determine θ.

(11) Prove that in any triangle

(i) $4\,R^2 (\sin^2 A+\sin^2 B+\sin^2 C) = a^2+b^2+c^2$

(ii) $a \cos A+b \cos B+c \cos C = R (\sin 2A+\sin 2B+\sin 2C)$.

Answers to Exercises in Lesson 25

(1) (i) 6·1. (ii) 7·28.
The greater frequency of the larger numbers in (ii) increases the mean, compared with (i).

(2) (i) 78. (ii) 2·6.

(3) Mean = 22·7 ins., frequencies are 2, 6, 13, 8, 1.

(4) Mean = 15 years, σ = 1·633 years,
S^2 (from 12) = 11·6,
S^2 (from 13) = S^2 (from 17) = 6·6,
S^2 (from 14) = S^2 (from 16) = 3·6.

LESSON 27

The Calculus: Speed, Acceleration and Rate of Growth

THE work we have already done now provides us with the trunk from which emerges a new and most important branch of mathematics—the *Calculus*. This is concerned with *rates of change*, and is basic in applied mathematics. Here, for example, are some typical illustrations:

At what rate does the level of water fall in a tank if a tap is opened at its lowest point? Notice that the rate of flow through the tap will depend on the height of water in the tank, and vice versa.

At what rate will the speed of a truck increase if it runs freely down a given gradient under gravity and against friction only? At what rate will the gas in a cylinder diminish in volume if the pressure on the piston is itself increased at a given rate? At what rate will a block of ice melt if heat is supplied to it at a given rate? At what rate will a bomb increase in speed if dropped from a given height?

Rates of Change. It will be seen at once that rates of change are fundamental to every branch of applied mathematics. We can illustrate the method by means of a simple example.

Suppose the side of a cube at any moment is x inches. Its volume is then $V=x^3$ cub. in. What is the rate of change of volume for each unit change in x?

Suppose x increases from x to $x+h$ where h is exceedingly small. Then the volume will increase from x^3 to $(x+h)^3$.

We use the symbol δ (Greek *delta*) to stand for the words *small change in*, so δV means not $\delta \times V$, but 'small change in volume.' Hence in the cube:

$$\delta V = (x+h)^3 - x^3 = 3hx^2 + 3h^2x + h^3.$$

The rate at which V is changing with increase h in length of side, will be the ratio of δV to h. Thus:

$$\frac{\delta V}{h} = 3x^2 + 3hx + h^2$$

Notice that as h is made smaller and smaller, δV becomes smaller and smaller so that $\delta V/h$ is tending towards the form 0/0, which, of course, is arithmetically meaningless. From the above, however, we see that a reasonable meaning to be given to this *limiting form* is the value that $3x^2+3hx+h^2$ attains when h becomes ultimately zero, viz., $3x^2$.

Thus we say that the rate of change of $V=x^3$ with x is $3x^2$. For example, a cube of side 100 in. has a volume of $10^6 = 1{,}000{,}000$ cub. in. and at that stage it will increase in volume by $3\times 100^2 = 30{,}000$ cub. in. per inch increase in x, a side.

Clearly if δV stands for a small change in V we can replace h by δx, a small change in x.

Now let us consider this more generally. Suppose $y=Ax^n$, where A and n are any numbers. We inquire at what rate y will change with x. From what we have just done it is clear that a small change in y, viz. δy, will be produced by a small change δx in x, where

$$\delta y = A(x+\delta x)^n - Ax^n.$$

In this, x may have any value, large or small, but δx is ultimately to be made *infinitesimally small*, so we write:

$$(x+\delta x)^n = x^n\left(1+\frac{\delta x}{x}\right)^x$$
$$= x^n\left(1+n\frac{\delta x}{x}+\frac{n(n-1)}{2!}\left(\frac{\delta x}{x}\right)^2+\ldots\right)$$

Hence

$$\delta y = Ax^n\left(n\frac{\delta x}{x}+\frac{n(n-1)}{2!}\left(\frac{\delta x}{x}\right)^2+\ldots\right)$$
$$= An\,x^{n-1}\delta x + \frac{An(n-1)}{2!}x^{n-2}(\delta x)^2 + \ldots$$

or

$$\frac{\delta y}{\delta x} = An\,x^{n-1} + \frac{An(n-1)}{2!}x^{n-2}\,\delta x + \ldots$$

On the left, as δx, and therefore also δy, becomes indefinitely small, the ratio takes the form 0/0 and is therefore meaningless unless we say its value is to be the expression on the right as δx tends to zero. On the right, therefore, we have ultimately Anx^{n-1}, and the meaning finally to be attached to the expression on the left is 'the rate of change of y with x.' In this limiting form we write the left as

$$\frac{dy}{dx}, \text{ i.e if } y=Ax^n \text{ then } \frac{dy}{dx}=An\,x^{n-1}.$$

$\frac{dy}{dx}$ is called the *derivative* or the *differential coefficient* of y with respect to x, and measures the rate of change of y with x at the position x.

Note that when $n=3$ this verifies the result already obtained.

Examples. The differential coefficients of

$$x^4,\ x^7,\ \frac{1}{x},\ \frac{1}{x^3},\ x,\ x^{\frac{1}{3}},\ 5, \text{ are}:$$

$$4x^3,\ 7x^6, -\frac{1}{x^2}, -\frac{3}{x^4},\ 1,\ \frac{1}{3x^{\frac{2}{3}}},\ 0.$$

If a function is composed of the sum of a series of separate terms then the whole function will increase as a result of the sum of the increases in the separate terms. It follows that the derivative of such a function will be the sum of the derivatives of each of the separate terms. Thus, for example :

if $\quad y = A + Bx + Cx^2 + Dx^3$

then $\quad \frac{dy}{dx} = B + 2Cx + 3Dx^2.$

Special Function. Consider the function

$$y = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \ldots .$$

a succession of terms which never ends. We shall assume that for any value of x this function has a definite value in spite of the fact that the succession is endless. The derivative of this function is, of course, obtained by differentiating term by term, thus :

$$\frac{dy}{dx} = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \ldots$$

which is the original function. Thus in this case the function increases at a rate measured by its own value. It is called the *Exponential Function*. It can easily be shown that the series given above can be closely represented in the form e^x where e is the number $2{\cdot}718$ . . . . approximately. Hence the rate of change of e^x is e^x. Clearly a function of this type applies to any population whose rate of growth is proportional to its size, a feature of many forms of propagation at the animal and vegetable level. It occurs also in cases of mechanical instability in which a disturbance increases at a rate proportional to its own size. Interest on capital continuously accumulating will also increase according to such a law.

Now consider a fluctuating function such as that given by $y = A \sin nx$. Can we discover the rate at which this changes with x ? If x increases to $x + \delta x$ then, of course, y increases to $y + \delta y$. Hence

$$\delta y = A \sin n(x + \delta x) - A \sin nx$$

$$= 2A \cos n(x + \frac{\delta x}{2}) \sin (\frac{n}{2}\delta x)$$

$$\frac{\delta y}{\delta x} = 2A \cos n(x + \frac{\delta x}{2}) \sin (\frac{n}{2}\delta x)/\delta x$$

$$= An \cos n(x + \frac{\delta x}{2}) (\sin \theta)/\theta$$

where $\theta = \frac{n}{2}\delta x$.

As we propose to make δx vanishingly small this implies that θ is to become vanishingly small. In that case $\cos n\left(x + \frac{\delta x}{2}\right)$ ultimately becomes $\cos nx$, but $\sin \theta/\theta$ takes the arithmetically impossible form of 0/0. What meaning have we to attach to $\sin \theta/\theta$ in this limiting case ?

In Fig. 130 θ is the angle AOB (in radians). The point P is the foot of the perpendicular AP on OB. The arc AB has its centre at O, so that OA = OB = r, say. AQ is the tangent to this arc at A, therefore AQ is perpendicular to OA.

Fig. 130. Sin θ is less than θ and less than tan θ if θ is in radians and is less than π/2.

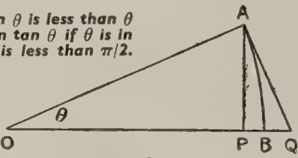


Fig. 130

AP = $r \sin \theta$, and since $\frac{AQ}{OA} = \tan \theta$, AQ = $r \tan \theta$. Since the area of the triangle OAB is less than the area of the sector OAB, which is itself less than the area of the triangle OAQ, it follows that :

area $\triangle$ OAB $<$ area sector OAB $<$ area $\triangle$ OAQ

i.e. $\frac{1}{2}$. OB . AP $< \frac{1}{2}r^2\theta < \frac{1}{2}$OA . AQ

i.e. $\frac{1}{2}r \cdot r \sin \theta < \frac{1}{2}r^2\theta < \frac{1}{2}r \cdot r \tan \theta$

or $\qquad \sin \theta < \theta < \tan \theta$ . . . .

provided θ is less than a right angle.

Dividing all along by $\sin \theta$, which is positive, we have

$$1 < \frac{\theta}{\sin \theta} < \frac{1}{\cos \theta}.$$

This is a relationship of inequality which sandwiches the value of $\frac{\theta}{\sin \theta}$ between 1 and $\frac{1}{\cos \theta}$. Now $\cos \theta$ is itself always less than 1, and, when θ is small, $\cos \theta$ is very nearly 1. Thus the smaller θ becomes, the more closely does $\frac{1}{\cos \theta}$ tend to 1, and therefore the closer are the limits between which $\frac{\theta}{\sin \theta}$ lies, and these limits are finally both 1.

Returning now to the expression for

$\frac{\delta y}{\delta x}$ for the case where $y = A \sin nx$, we see that in the limiting situation where δx becomes vanishingly small

$$\frac{dy}{dx} = An \cos nx.$$

Example. If $y = \sin x$, the rate of change of y with x is

$$\frac{dy}{dx} = \cos x.$$

It can be shown in the same way (or it can be deduced from the foregoing) that if

$$y = A \cos nx \text{ then } \frac{dy}{dx} = -An \sin nx.$$

Illustration. Suppose an electrical conductor is being charged through a wire with a fluctuating charge Q given by $Q_0 + Q_1 \sin pt$ where Q_0, Q_1, and p are constants, and t is the time in seconds. Thus at time $t=0$ the charge is Q_0. It rises to Q_0+Q_1 after $\pi/2p$ secs., falls to Q_0 again after π/p secs, and drops to a minimum of Q_0-Q_1 after $3\pi/2p$ secs. What is the strength of the current flowing along the wire ?

Since the charge flows to and fro along the wire, the current in the latter is measured simply by the rate of change of the charge. Thus current$= \frac{dQ}{dt} = Q_1 p \cos pt$. Thus the current is a maximum when the charge is a minimum, and vice versa. The maximum current is $Q_1 p$, and its period is $2\pi/p$.

Graphical Meaning of Differentiation. Consider the graph of $y=f(x)$ illustrated in Fig. 131. Here P is the point (x, y) that is $(x, f(x))$. A neighbouring point Q is therefore $(x+h, f(x+h))$.

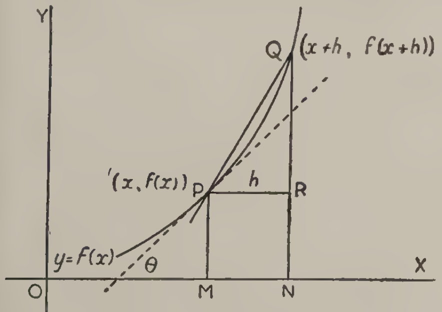


Fig 131

$$RQ = NQ - MP = f(x+h) - f(x).$$

Since $PR = h$, the slope of the chord PQ is $RQ/PR = [f(x+h) - f(x)] / h = \delta y / \delta x$ if $h = \delta x$.

It follows that as δx tends to zero, when $\delta y/\delta x$ is then written $\frac{dy}{dx}$, that the derivative is really the slope of the limiting position of a chord joining two neighbouring points that finally fall together. Hence $\frac{dy}{dx}$ is the slope of the tangent at the point (x, y) on the graph of $y=f(x)$.

Example. To find the equation to the tangent at the point (1, 1) on the parabola $y=x^2$. The derivative of $y=x^2$ is $\frac{dy}{dx} = 2x$, and hence the tangent at (1, 1) has a slope of $2 \times 1 = 2$. Since the line through (1, 1) is

$$y-1 = m(x-1)$$

and $m=2$ the required tangent is given by

$$y-1 = 2(x-1)$$

or

$$y = 2x-1.$$

Kinematic Meaning of Differentiation. If a body is in motion, its speed is measured by the rate at which its distance from a fixed point increases or diminishes. Hence if s, the distance passed over, is plotted against t the time taken, the slope of the tangent to this curve will give the speed of the body at that time and place. If, of course, we know the equation to the distance-time graph we can derive the formula for the speed by direct differentiation. For instance, if a body is projected vertically upwards against gravity it is found that the height s (in feet) reached t secs. after projection, is given by a relation of the form :

$$s = ut - 16t^2$$

where u is some constant.

The speed at any time t, viz. $\frac{ds}{dt}$ is therefore found by differentiating this, viz.,

$$\frac{ds}{dt} = u - 2 \times 16t = u - 32t.$$

At the starting point, $t=0$, so the starting speed is u. If we write v for the velocity at time t then $v = u - 32t$ ft. per sec.

Again the acceleration is the rate of change of speed, hence if we differentiate v we obtain the acceleration. Thus

$$\frac{dv}{dt} = -32 \text{ ft. per sec. per sec.}$$

Thus a body projected vertically upwards is *retarded* with a constant acceleration (or deceleration) of 32 ft. per sec. per sec.

Oscillating Motion. If the distance of a body from its starting point is given by $s = A \sin nt$ then, since $\sin nt$ oscillates between $+1$ and -1 in value, this will represent a swinging motion of amount A on each side of the initial position. The speed, by differentiation, will, of course, be

$v = \frac{ds}{dt} = A\ n \cos nt$, and the acceleration

$$\frac{dv}{dt} = -A\ n^2 \sin nt = -n^2 s$$

Thus, in this case the acceleration is always proportional to the displacement s from the starting point; and since there is a negative sign it will act in opposition to the direction of the displacement. A motion following this law is called *Harmonic Motion* (*see* Physics, Vol. I, p. 355), and is found in the vibration of a tuning fork, a plucked wire, a pendulum, or an extended elastic string when released. It is the motion usually set up in any stable system when slightly disturbed from its equilibrium position.

Integration. The *Integral Calculus* poses the inverse problem to that posed in the differential calculus. It says: if we know the rate of change—can we find the total change? If we know the speed, varying as it does from second to second, can we find the total distance gone? If we know the acceleration, can we find the speed? We ask, in fact, from what function did this given differential coefficient come? Let us examine the relation in this way.

Fig. 132 shows the graph of $y=f(x)$ from any given position LM up to PQ where $OQ=x$. Thus P is *any* point on the curve. Let A=area of LMQP and let us seek the rate at which this area changes as x increases. Accordingly, we let x increase to $x+\delta x$, that is Q changes to Q′ and P to P′. The increase in area, viz. δA, is then PP′Q′Q, which is approximately PQ×QQ′, i.e. $f(x)\times\delta x$.

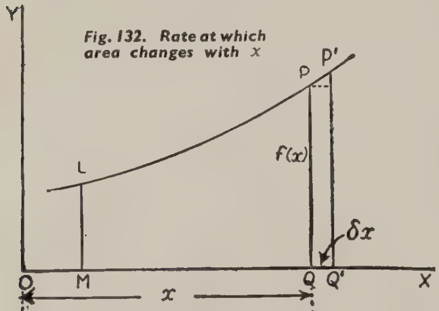


Fig. 132. Rate at which area changes with x

Fig 132

Thus $\delta A=f(x)\times\delta x$.

(Actually PP′Q′Q is not exactly a rectangle, but the error in assuming this is itself infinitesimally small in comparison with the area of the rectangle.)

Two conclusions can be seen to follow:

1 $\frac{dA}{dx}=f(x)$.

Thus the ordinate of the curve measures the rate of change of the area between the curve and the x axis.

2. If we add up all these strips δA from the position LM to any position x we obtain an estimate of the above area. If we use S to stand for the words ‘ sum of all the elements,’ then

$$A=S\,f(x)\,.\,\delta x$$

and the smaller δx is made the less approximate does this statement of equality become.

In the limiting case, where δx is made infinitesimally small therefore, we write dx in place of δx, and replace S by a long s like this: $\int$. Thus

$$A=\int f(x)\,dx.$$

We say that A is the integral of $f(x)$.

Conclusion 1 sets out against it the alternative statement:

$f(x)$ is the differential coefficient of A.

In both A is the area between M and Q.

Example. If $f(x)=2x$ then, since the differential coefficient of x^2 is $2x$, it follows that $A=x^2$. Notice, however, we have not stated our result in sufficiently general terms. For $2x$ is also the differential coefficient of x^2+C where C is any number. Hence if

$$\frac{dA}{dx}=2x$$

$$A=\int 2x\,.\,dx=x^2+C.$$

The constant C will be found by specifying from which point M the area is to be measured. For example, if M coincides with the origin, then $A=0$ when $x=0$. Since $A=x^2+C$ it follows that $C=0$. Thus, in this case $A=x^2$.

Example. To find the area between the parabola $y=x^2$ and the x-axis as far as $x=1$.

$$A=\int x^2\,dx=\frac{1}{3}x^3+C.$$

When $x=0$, $A=0$; hence $C=0$. Thus $A=\frac{1}{3}x^3$ up to any value of x. When $x=1$ therefore $A=\frac{1}{3}$, which is the required area.

How the Calculus is Used. 1. To determine how the level of water falls in an open rectangular tank as the contents are discharged through an orifice in the base.

Let the water level be H ft. initially above the base, the area of the surface A sq. ft., and of the orifice a sq. ft. If y ft. is the height at any time t,

the rate of fall is $-\frac{dy}{dt}$, and the rate of loss of volume is $-A\frac{dy}{dt}$.

Thus, if v is the speed through the orifice, this loss is also av.

Hence $$-A\frac{dv}{dt}=av$$

Now the energy of this discharged water is that derived from falling a height y.

$$\text{Hence } \tfrac{1}{2}v^2=gy \text{ or } v=\sqrt{(2gy)}.$$

$$\text{Thus } -\mathrm{A}\,\frac{dv}{dt}=a\sqrt{(2g)}\,.\,y^{\frac{1}{2}}$$

Had we taken a small horizontal slice of the liquid, of thickness δy and considered what happens to it in time δt, we would get the approximate equation :

$$-\mathrm{A}\,\frac{\delta y}{\delta t}=a\sqrt{(2g)}\,.\,y^{\frac{1}{2}}$$

i.e. $$-y^{-\frac{1}{2}}\cdot\delta y=\frac{a}{\mathrm{A}}\sqrt{(2g)}\,.\,\delta t$$

Summing up the elements on both sides we obtain :

$$-\int y^{-\frac{1}{2}}\,dy=\frac{a}{\mathrm{A}}\sqrt{(2g)}\int dt$$

or $$-2\,y^{\frac{1}{2}}=\frac{a}{\mathrm{A}}\sqrt{(2g)}\,.\,t+\mathrm{C}$$

where C is a constant.

Since $y=\mathrm{H}$ when $t=0$; this means that $\mathrm{C}=-2\mathrm{H}^{\frac{1}{2}}$.

Hence finally $-2y^{\frac{1}{2}}=\frac{a}{\mathrm{A}}\sqrt{(2g)}\,.\,t-2\mathrm{H}^{\frac{1}{2}}$

or $$y=\left(\frac{4at}{\mathrm{A}}-\sqrt{\mathrm{H}}\right)^2$$

It follows that the tank will empty, i.e. $y=0$ when $t=\dfrac{\mathrm{A}\sqrt{\mathrm{H}}}{4a}$ secs.

2. To find the volume of a right circular cone the radius of whose base is a, and height of cone h.

Take the origin at the vertex, and the x-axis along the axis of the cone. A plane at right angles to the axis at distance x from the origin will cut the cone in a circle of radius xa/h. The area of this circle is therefore $\pi a^2x^2/h^2$. If now the cone be cut by a parallel plane at distance $x+\delta x$ from the origin the volume of the small cylinder between the two planes will be $\delta x\times\dfrac{\pi a^2x^2}{h^2}$. This is the increase in volume V of the cone lying between $x=0$ and the plane through x on the axis.

Thus $$\delta\mathrm{V}=\frac{\pi a^2}{h^2}\,x^2\,\delta x.$$

Summing up these elements, that is integrating, we obtain :

$$\mathrm{V}=\frac{\pi a^2}{h^2}\int x^2dx=\frac{\pi a^2}{3h^2}\,x^3+\mathrm{C}.$$

When $x=0$, $\mathrm{V}=0$. Hence $\mathrm{C}=0$. Thus volume from $x=0$ to x is $\pi a^2x^3/3h^2$. Hence when $x=h$, for the whole cone, the volume is $\pi a^2h^3/3h^2=\pi a^2h/3$.

3. To find the volume of a sphere of radius a. Take the origin at the centre of the sphere. At a point x on the x-axis, slice the sphere by a plane at right angles to this axis. It will cut the sphere in a circle of radius $\sqrt{(a^2-x^2)}$, and therefore of area $\pi(a^2-x^2)$. Slice the sphere by another plane parallel to the first through the point distant $x+\delta x$ from the origin. These two planes cut off a volume which is approximately a cylinder of volume $\pi(a^2-x^2)\,\delta x$. Thus, if V is the volume from the parallel plane through the origin to the plane through x, then

$$\delta\mathrm{V}=\pi(a^2-x^2)\,\delta x.$$

Summing these elements up, that is, integrating, we get :

$$\mathrm{V}=\int\pi(a^2-x^2)dx=\pi a^2\int dx-\pi\int x^2dx$$
$$=\pi a^2x-\pi x^3/3+\mathrm{C}.$$

Since $\mathrm{V}=0$ when $x=0$, therefore $\mathrm{C}=0$.

Hence $\mathrm{V}=\pi a^2x-\pi x^3/3$.

When $x=a$, V becomes the volume of half the sphere. Thus :

$$\mathrm{V}=\pi a^2\times a-\pi a^3/3=2\pi a^3/3.$$

Hence total volume of sphere $=4\pi a^3/3$.

Note.—Volume of a spherical cap cut off by a plane at distance x from the origin is $2\pi a^3/3-\pi a^2x+\pi x^3/3$, or, if the depth of the cap is h, so that $h=a-x$ the volume of the cap is :

$$2\pi a^3/3-\pi a^2(a-h)+\pi(a-h)^3/3=\pi h^2(a-h/3).$$

EXERCISES

1. Differentiate :

$3x^6$, $\dfrac{1}{x^3}$, x^3+x, $\sin 2x$, $7x^4+5x$, $3x^{\frac{1}{3}}-x$, $9x^{-3}+4x+7$, $6x^2+4e^x+\cos x$.

2. Find the speed of a particle whose distance s at time t is given by :

$$\frac{1}{t},\ (2t^2+3)/t,\ 4-2t-5/2t$$

3. By expanding each of the following expression in powers of x, find dy/dx.

$$y=(x^2-1)\ \ (1+2x),\quad y=(x+2)^3,$$
$$y=(x^3+2x+1)/x^3.$$

4. Find the area between the curve, the axis of x and the ordinates at $x=0$ and $x=1$ in each of the following cases :

$$y=x^4,\ y=\sin\,\pi x,\ y=\cos\,(\pi x/2).$$

5. Find the tangent to the curve $y=x\,(x^2-4)$ at the point (2, 0).

Answers to Exercises in Lesson 26

(1) A=36° 36′, B=83° 24′, c=4·359″.
(2) A=81° 1′ or 18° 59′. (6) 6·14.
(9) R=8·125 ft., r=4 ft., △=84 sq. ft.
(10) θ=35° 39′.

LESSON 28

What is Mathematics?

We have progressed in a series of steps, sometimes irregular like the advances of a military force consolidating a position, before a further advance is made, from the use and meaning of numbers, or integers, to the preliminary study of the integral calculus. In that progress we have provided the student if he has, on his part, given it adequate and serious attention, with the apparatus for his own further development in the fascinating mental discipline that mathematics affords. Arithmetic, algebra, plane and coordinate geometry, trigonometry, logarithms and the slide rule, the calculus—all these fields have been opened with indications of the practical uses and applications of the operations described in them.

The student is strongly advised, as in all departments of science and technics, to make certain of his ground before each fresh advance. This he can do by checking his knowledge and grasp with the help of the exercises provided with each Lesson. At this stage he may proceed with further studies, in general or in particular branches of mathematics, by selecting appropriately from the list of books at the end of the Course.

Having now acquired a basis of mathematical knowledge, we may usefully consider some of its philosophical and historical aspects and ask 'What is Mathematics?', a question better answered at this stage than at the beginning of our studies.

Mathematics has developed in response to a variety of needs. Engineering and physical science, for example, have thrown up certain problems at critical periods in their history, that have called urgently for solution. Thus, at the end of the 16th and the beginning of the 17th centuries the growth of merchant trade and with it the need for overseas communication gave a new stimulus to shipbuilding, turned attention to a close study of tides and of the movements of stars and planets, so important as an aid to navigation. We can well imagine, therefore, that many questions of physical and engineering science pushed their way to the fore at that time—problems concerned with the resistance of bodies in their motion through water and air, efforts to predict the position and motion of planets involving therefore a recognition of law and order among the heavenly bodies, problems on the effect of the Earth's rotation and of the attraction of the sun and the moon on the height of the tides. All these, involving as they do the setting up of theories, demanded also the creation of a mathematical technique to assist in analysing these theories and drawing from them conclusions of practical value.

Period of Discovery. The scope of the subject already dealt with in the earlier Lessons of this Course, sufficed for Newton and his contemporaries to handle these issues. They formulated the Three Laws of Motion that connect forces in operation with the speeds and accelerations produced by their action. They formulated the laws of planetary motion, and the Law of Gravitation, and showed that from the assumption that any two bodies in space attract each other with a force inversely proportional to the square of the distance between them, it followed mathematically that the Earth moved round the sun in an ellipse with the sun at a focus, that the radius joining the Earth to the sun swept out equal areas in equal times, and that for all the planets the squares of the times taken to make a complete circuit of the sun were proportional to the cubes of the distances of these planets from the sun.

This was the period, therefore, when a new lease of life was given to the study of algebra, trigonometry, and similar branches of mathematics ; but above all it was the period of the discovery and development of the differential and the integral calculus. For the latter, concerned as it is with rates of change and the calculation of distances passed over under conditions of varying speeds, provided precisely the mathematical tools to solve the complex problems of astronomy and physics that had pushed their way to the front.

The Logic of Development. But a topic like mathematics does not develop only in response to this kind of social pressure. The subject itself has an inner logical drive that inevitably poses mathematical problems that call for an answer. Take the step for example between ordinary arithmetic and algebra, and the calculus. In the former a quantity, or a set of symbols like 0/0, could have no meaning. Division by zero was necessarily excluded since that operation could not in fact be performed, and to divide zero by zero would have been merely to add nonsense to nonsense. Nevertheless the idea of a rate of change was definite enough ; and a rate of change demanded the division of a small distance by a small time, and the continuance of that operation until both the distance and the time became vanishingly small.

To make the extension to the calculus possible, so necessary for other reasons, it was essential to set about a reconsideration of the detailed logic of this process, so that at one and the same time it could remain consistent with ordinary rules of algebra, and yet give a sensible meaning to 0/0.

Out of this therefore emerged the new theory of limits, and in this way not only were new developments possible into the differential and the integral calculus, but other fields such as the study of infinite series were opened out. Thus when society requires to solve practical problems of a novel nature, it tends to evoke new forms of mathematical technique ; these in their turn force a reconsideration of the logical basis of the subject, and when this has been successfully completed, other branches of mathematics tend to be opened up that have not necessarily any immediate practical application. The scope of mathematics thus extends both by external and by internal pressure.

How Numbers Arose. We can see this again even in the earliest stages of arithmetic. It is easy enough to understand how the marks arose that correspond to the integers. The figures or shapes were in fact pictures, words, or symbols, to stand for groups of various sizes. It is obvious therefore that in this setting there would be no place for the symbol 0, as it does not stand for a group at all. Nevertheless early Indian traders appear to have found it necessary to have some mark to represent the fact that a debt had been paid off, or that nothing was outstanding. It is believed therefore that the invention of the zero mark arose out of the needs of early commerce. Once that had been accomplished it became possible by giving a meaning to the order in which numbers were written down to use the ten symbols, and no more than these, to represent a group of any size. The symbol 0 took its appropriate place in this system by asserting, that where it appeared, there were no members of the particular group that corresponded to the place occupied by 0.

From that moment Arithmetic became a subject for scientific study. Since it was now possible to write down any number of the infinite set of integers with no more than the ten different symbols 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, the whole field of integers could be examined for its properties. Rules were discovered for the finding of factors. It was proved that there were an unlimited number of prime numbers, and many new discoveries about such numbers have been laid bare. Some have been discovered, but have not been proved. For example, it is always possible in any particular case to show that an even number can be written as the sum of two prime numbers, but no one has ever succeeded in establishing this simple proposition for *any* even number. Arithmetic grew under the drive of its own logical necessities once practical needs had called it forth.

Symbols and Abstract Thought. Mathematical symbols, and the logical process they express in a mathematical argument when written on paper, are really an objective way of describing a process of thought. Anyone who has written down a mathematical argument can hand the paper to someone else, and if he will follow it, the latter can trace again the process of thought through which the former went. It is a concise method of registering a succession of thoughts, once for all. Years afterwards an individual may pass again through the same logically connected group of thoughts as he passed through at an earlier stage, merely by consulting his mathematics.

Now the significant point about this lies in the refined or abstract nature of the thinking involved. In most other situations one's thoughts, the connexion between thoughts, and the weighing of the relative importance of one argument against another, are very profoundly influenced by one's feelings and one's past experience. In general, thinking and feeling are very closely interwoven, as is clearly evident in the extreme case where a person decides to do something—that is, thinks out his course of action—in a fit of temper. It is not possible to evade a mathematical conclusion whatever one's state of feeling. One does not say that the three angles of a triangle are equal to 190°, just because one is angry. The whole setting, and the ideas involved, are so abstract that the logic is compelling. If feeling enters, it does so in registering agreement with the steps of the argument, or in the aesthetic sense of pleasure that arises in appreciating the meaning of a proposition.

Nature of General Propositions. The nature of the abstraction involved in mathematical reasoning is well worth closer study, for in it lies the peculiarity of mathematics that makes possible the stating of propositions of very wide generality. When we draw a triangle on a sheet of paper, and by means of it we prove some general proposition, such as that the three angles together amount to 180°, how is it that from this very particular triangle we can deduce something of such wide generality ? Moreover if we examine very closely the figure we have drawn, it will be seen that it is not a triangle at all, but three rather uneven marks on the paper, with possibly rather blunt corners. The fact that it is so seems to make no difference to the proof !

The point is, of course, that the triangle we have drawn is really an object—a mathematical object composed of fine particles of graphite and paper. If we look at the world about us we can easily find a stone or a piece of wood from which, by forgetting everything except the shape, we ' abstract' the idea of a triangle. A triangle is an idea, not an object. It is a mental image drawn from the real world. It is an image composed of the idea of three straight lines, each of which is itself an idea drawn from the real world. In order to discuss these ideas it is convenient to have an object from which to abstract them when necessary, but it would certainly not be convenient to carry around with us pieces of wood and stone for this purpose. So the mathematician makes his own object, a much simpler one, a set of marks on a piece of paper, and this he calls a triangle. It is of course a misnomer, because the triangle he discusses is really the idea and not the mathematical object, which is a material triangle.

If we can see this distinction between the ideas which are discussed, and the mathematical objects that are used to help in the abstraction, it becomes at once clear why the mathematician is able to deduce general propositions from particular figures. He does not really deal with these figures in one sense, but ideas derived from them, and such ideas since they leave out a mass of particular characteristics of the figure are necessarily always much more general than the figure itself would appear to indicate.

Along such lines, therefore, can we come to an appreciation of the basic notions of mathematics, and the forces that have stimulated its growth. In itself it represents one of the finest efforts of civilized thought, and one of the most powerful instruments for social change.

Answers to Exercises in Lesson 27

1. $18x^5, -\frac{3}{x^4}, 3x^2+1, 2\cos 2x, 28x^3+5, \frac{1}{x^{2/3}}-1, -27x^{-4}+4, 12x+4e^x-\sin x.$
2. $-1/t^2, 2-3/t^2, -2+5/2t^2.$
3. $6x^2+2x-2, 3(x+2)^2, -\frac{4}{x^3}-\frac{3}{x^4}$
4. $1/5, 2/\pi, 2/\pi.$
5. $y=8x-16.$

BOOK LIST

General. ' Mathematics for the Million,' L. Hogben (Allen & Unwin) ; ' Mathematician's Delight,' W. W. Sawyer (Penguin) ; ' Nature of Mathematics,' M. Black (Kegan Paul) ; ' Elementary Mathematics,' H. Levy (Nelson); ' Introduction to Mathematics,' A. N. Whitehead (Butterworth) ; ' Pure Mathematics,' G. H. Hardy (C.U.P.) ; ' Elementary Treatise on Pure Mathematics,' N. R. C. Dockeray (Bell) ; 'Mathematical Recreations and Essays,' W. W. Rouse Ball (Macmillan) ; ' What is Mathematics ? ' R. Courant and H. Robbins (O.U.P.).

Geometry and Trigonometry. 'Analytical Geometry,' B. C. Molony (Bell) ; 'Foundations of Geometry,' G. de B. Robinson (O.U.P.) ; 'Modern Trigonometry,' M. J. G. Hearley (Nelson) ; 'Elementary Trigonometry,' Prescott and Lowry (Longman) ; 'Trigonometry,' (4 Vols.). T. M. MacRobert and W. Arthur (Methuen).

Algebra. 'Algebra,' W. L. Ferrar (O.U.P.) ; 'Theory of Equations,' H. W. Turnbull (Oliver & Boyd).

Calculus. 'Elementary Calculus,' F. Bowman (Longman) ; 'Infinitesimal Calculus,' H. Lamb (C.U.P.) ; 'Elementary Treatise on the Calculus,' G. A. Gibson (Macmillan).

Statistics. 'Elementary Statistics,' H. Levy and E. Preidel (Nelson) ; 'Statistical Mathematics,' A. C. Aitken (Oliver & Boyd).

History of Mathematics. 'Mathematics for the Million,' L. Hogben (Allen & Unwin) ; 'The Great Mathematicians,' H. W. Turnbull (Methuen).

FOREIGN LITERATURES

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19 LESSONS

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LESSON ONE

French I: 'Chanson de Geste' to Malherbe

THE earliest French literature is ecclesiastical; there are some charming legends of the saints and various didactic poems. Practically nothing survives of the primitive verses, or *cantilènes*, which the Frankish troubadours extemporized to celebrate notable occasions, but from them the *chansons de geste*—songs of heroic deeds—developed.

Chansons de Geste. These glorified the prowess of heroic figures; their background was feudal France. They were sung or chanted by wandering jongleurs or troubadours who provided a musical accompaniment—harp, fiddle or hurdy-gurdy. To avoid tedium the narrative was divided into episodes which could be wound up at will by the interpolation of a few concluding lines. These episodes, like those of 'The Arabian Nights,' their prose counterpart in the East, were transmitted by word of mouth from one generation to the next, and were supplemented and embellished by successive jongleurs, until finally they were set down in manuscript.

The chanson de geste flourished especially in the 11th and 12th centuries; altogether 95 are still extant. They can be regarded as falling into three main groups: the cycle of Charlemagne, the cycle of Guillaume, or Monglane, protector of Charlemagne's weakly son, and the cycle of Doon de Mayence, a rebellious vassal of Charlemagne. In their original form they amounted to well over 300,000 lines. Metrically they were divided into *laisses* or stanzas of varying length, each held together by a single assonance or vowel rhyme. The lines were usually decasyllabic, but might be octosyllabics or alexandrines (twelve syllables).

The Chanson de Roland. Most famous of these early epics is 'La Chanson de Roland' (11th cent.), which belongs to the Charlemagne cycle, or 'Geste du Roi.' In some 4,000 lines, divided into five sections, each with numerous episodes, it tells the adventures of Charlemagne's nephew Roland, culminating in his courageous rearguard action against the Saracens at the Pass of Roncevaux in the Pyrenees, and his noble death, fighting alone, for 'la dulce France.' The struggle between France, as champion of Christendom, and her pagan enemies, is idealized, and a rare beauty and nobility are achieved.

The Charlemagne cycle also includes the well known 'Huon of Bordeaux.'

Romances. Of later growth are the very considerable group of poetic romances. In place of the simple grandeur of the chanson de geste, the *roman courtois*, or courtly romance, gives us the complications of knightly adventure and chivalrous love, with a mystical tinge. Whereas the chanson de geste had dealt with old French traditional history ('la matière de France'), the roman courtois ranges farther afield, even into the realms of faery.

Again there are three main cycles: the Breton cycle, centring round King Arthur and including the story of Tristram and the legend of the Holy Grail; the cycle of antiquity, in which Greek and Roman heroes play their part, notably Alexander the Great; and the *roman d'aventure*, stories such as the well-known 'Guy of Warwick' and 'Florys et Blanchefleur,' sometimes of Byzantine origin absorbed during the Crusading period. There is also a group of prose romances, of which the lovely 'Aucassin et Nicolette' (13th century) is best known. Most of these romances are by unknown authors, but the name of Chrétien de Troyes should be remembered; he wrote several Arthurian poems of great literary merit, which, translated by the German minnesingers, had an extended influence. The French Arthurian cycle was itself inspired by the Latin chronicles of Geoffrey of Monmouth, which were rendered into French verse by the Jersey poet Wace. Many of these medieval romances found their way into English literature (*see* Volume I, pp. 86–87).

Fabliaux. Characteristically French are the fabliaux, tales of everyday life, usually humorous, in verse; Chaucer and Boccaccio drew largely on these. An offshoot from them was the remarkable 'Roman de Renart,' or 'History of Reynard the Fox,' which was the nucleus of a cycle of long narrative poems amounting altogether to 100,000 lines. These were extremely popular in the 14th and 15th centuries; the animals represent the chief figures in Church and State, treated allegorically.

'Le Roman de la Rose.' The allegorical vein is also present in the beautiful 'Roman de la Rose,' one of the most important poems in medieval European literature. A love poem, crammed with adventure and wise discourse, it expresses the gaiety, the tenderness and the mysticism of chivalry at its finest; and it contains an extraordinary miscellany of scholarly thought and satirical comment on the times. Not only is it the epitome of the Middle Ages; it is also imbued with the humanism of the Renaissance. Its psychological profundity is something entirely new to the period.

‘Le Roman de la Rose’ was the work of two poets. Guillaume de Lorris wrote the early part (*c.* 1225), with its ardent adventures and its gracious revelation of the art of love; about a century later the scholarly Jean de Meung expanded it from 4,670 lines to 22,818 lines. The influence of this famous poem was marked throughout Europe. Chaucer translated a portion of it. In the 16th century Clément Marot, himself a memorable poet, took the archaic text and rendered it into contemporary French, thus giving it a new lease of life.

Early Lyrics. Lyric poetry was in full flower from the 12th century onwards. It appeared first in the North, where the trouvères (wandering minstrels) helped to spread it; in the South, Provence was its especial home, whence the troubadours carried it to Italy and elsewhere. Love was the theme of many of their songs. In the 14th century, new forms emerged: the *rondel*, now known as the triolet; the *ballade*, which had three stanzas and an envoi; the noble *chant royal*, with five stanzas of 11 lines, using the same rhymes throughout, with a refrain; the *lai*, of 12 or 24 couplets, with two rhymes and a refrain; and the *virelai*, with stanzas of 4 to 7 lines of varying length.

Much of this early poetry is anonymous, but the names of no fewer than 400 troubadours are known to us, besides many trouvères, the former living in the South, the latter in the North, during the 12th and 13th centuries. Chrétien de Troyes, the romance-writer, was among the trouvères, as was Blondel de Nesle, the favourite minstrel of Richard Coeur de Lion. A writer of charming lais was the lady known as Marie de France, who lived at the court of Henry II of England.

VILLON. The first truly great French poet, François de Montcorbier was the protégé of a priest whose name he adopted. This portrait is from Clément Marot's edition of his work, published in 1533.

Drama. Dating from the 12th century we find the beginnings of drama in the ‘mysteries’ and ‘miracle plays,’ which at first were performed by the clergy in the churches, pictorializing Bible history and the lives of the saints, in order to convey their teaching more vividly. Later came the ‘moralities,’ which were allegorical or based on secular subjects, often classical; these were written and performed by companies of lay actors, either in the open air or in a hall. The sotie, or social satire, developed from these; Pierre Gringoire, ‘Prince des Sots,’ excelled in this genre. The popularity of humour led to the production of downright farce with no purpose except to amuse; of such, the delightful ‘Maître Patelin’ (15th century) is the chief survivor.

Chroniclers. Of the historians, the first to write in French prose was Geoffroi de Villehardouin, in the 12th century; his ‘Conquête de Constantinople’ is a glowing picture of Crusading times. In the following century Joinville's ‘Life of St. Louis’ is the highlight. These bring us to Froissart, whose ‘Chronicles’ have held the admiration of English readers ever since Lord Berners' excellent translation gave them to us (1523–25).

In this Jean Froissart (1337–*c.* 1400) we have a historian with a gift for picturesque writing, who set out to relate the feats of arms which occurred in the wars between France and England throughout the period 1326–1400; and a gorgeous, exciting pageant it is. Froissart was also an accomplished poet. As secretary to Queen Philippa, wife of Edward III, he had travelled widely.

A more solid historian was Philippe de Commines, who in the reign of Louis XI wrote his ‘Mémoires.’ Gone for ever are the ‘preux chevaliers' of Froissart's day; instead we have the modern scholarly technique.

Medieval Poetry. Notable minor poets of the early 15th century were Christine de Pisan, Alain Chartier and, especially, Charles d'Orléans, the prince who was captured at the Battle of Agincourt and spent a quarter of a century as a prisoner in England, consoling himself with exquisite melancholy verse.

It is not until we come to François Villon (b. 1431) that we find a truly great poet. Little is known of his life, but it was evidently a reckless full-blooded medley of vagabondage, brawling, poverty and even crime. In 1455 he was involved in a street fight and accidentally killed a quarrelsome priest; he had to flee from Paris to escape hanging. Afterwards he was frequently in prison and was condemned to be hanged for another offence; the sentence was commuted to banishment for ten years, in 1463, and thenceforward no trace of him remains. His well-known 'Ballade des Pendus' and 'Ballade de l'Appel' were written while under sentence.

RABELAIS. Under powerful patronage, François Rabelais, at heart a reformer, satirized Catholics and Calvinists alike in his encyclopedic burlesque.

The Louvre

Villon's ideas are simple and familiar, coloured with his own experience and so hauntingly expressed that he touches the deepest springs of the human heart. He loves life and protests vehemently against the ills of circumstance, flinging scorn upon those who harass him and uttering pity for suffering humanity, for the fading of beauty and for the troubles of old age; death is a terror which lurks continually in the background of his thoughts.

He was not a prolific writer; the bulk of his work is to be found in his 'Grand Testament,' in which he makes quaint bequests to friends and enemies. Throughout, as in his 'Petit Testament,' lovely ballades and rondeaux are scattered, such as the immortal 'Ballade des dames du temps jadis,' with its refrain

> Mais où sont les neiges d'antan?
> (But where are the snows of yesteryear?)

'La Belle Heaulmière' is a sombrely magnificent address to a once-famous beauty, now faded and approaching the inescapable extinction that was Villon's conception of death, over which he meditates starkly. Another impressive poem is the 'Ballade pour prier Nostre Dame,' written at his mother's request and enshrining the faith of an untaught woman. In the freshness of his work and its passionate intensity, Villon is a precursor of the Renaissance. He marks the end of the Middle Ages.

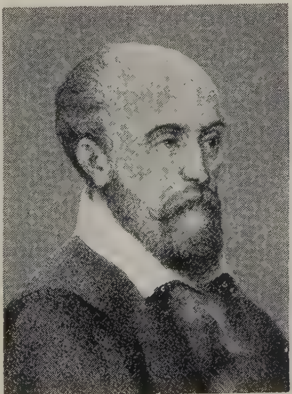
The Renaissance. The 16th century in France, as elsewhere in Western, Central and Southern Europe, was dominated by the Renaissance and the Protestant Reformation which accompanied it. It was the age of 'New Learning,' in which a broad humanism not only sought to recover the great standards of ancient cultures, but, stimulated by the revelation of man's potentialities, strove to outdo the past. Humanism has been defined as 'the effort of men to think, to feel, to act for themselves, and to abide by the logic of results.'

Rabelais. Now appeared François Rabelais (*c.* 1490–1553), a typical representative of the Renaissance in France. He was a doctor by profession, but he was also a humanist and, furthermore, a polymath—that is, a man of various and prodigious learning. For a long time he had an unenviable reputation in England, because of passages in his works which were deemed to be obscene. But the rollicking 'Chronicles of Gargantua and Pantagruel,' a story of giants, is immortal because of its gigantic conception of life and the spirit of laughter that invigorates it. Yet behind the laughter there is always the philosopher, anxious to produce ideas that aid human progress. Our instincts must be marshalled by culture; nature must be aided by science. That is the essence of Rabelais' teaching. One must not look for order or definite plans in his book, or for details on any one subject. It is the spirit of the whole, a tolerance based on belief in the fundamental goodness of man, that one must accept or reject. By the most enlightened standards, Rabelais stands out as a great man. As a writer his

MONTAIGNE. The first great essayist and one of the finest products of the Renaissance, Montaigne, by his profoundly thoughtful but never ponderous musings, had a civilizing effect on his readers.
Musée Condé, Chantilly; photo, Giraudon

style is clear and spontaneous, with an exuberance of vocabulary which is characteristic of his abounding vitality.

Contemporary with him was Marguerite d'Angoulême (1492–1549), sister of Francis I; she became, by her second marriage, Queen of Navarre. A fluent and versatile writer, she will be remembered for the diverting 'Heptaméron,' consisting of some seventy-two stories strung together after the manner of Boccaccio's 'Decameron.' In very different style wrote Jean Calvin (1509–64), whose monumental theological work, 'L'Institution Chrétienne,' provided a lucid exposition of his rigid and repressive doctrines.



RONSARD. There are no lovelier lyrics than Ronsard's. He was the brightest star of the Pléiade and his glory remains unsurpassed. He lived in court circles.

Montaigne. Of hardly less importance than Rabelais is that other great humanist, Michel Eyquem, (1533–92), Sieur de Montaigne, near Bordeaux, whose 'Essais,' read throughout the world, are altogether unique. One can say that here is a man who bases life on reason, who will have no explanation of anything which does not satisfy the reasoning powers of man. Consequently he has been called a sceptic, but this description of him is too superficial; Montaigne believes in man's noble qualities. The Essais deal with almost the whole range of contemporary thought, flitting nonchalantly from idea to idea, from subject to subject, rarely reaching fixed conclusions, but stirring the reader to meditate. Written in flawless style, they open and conclude so naturally that one thinks of them as effortless; actually this is the perfection of art. We are fortunate in having Florio's translation (1603), which has influenced English writers from Shakespeare to George Bernard Shaw.

Poets of the Renaissance. In poetry, the next noteworthy figure, after Villon, was Clément Marot (1497–1544). Though not one of the greatest poets, Marot was a consummate artist, and he had that untranslatable quality, 'esprit.' He excelled in madrigals, in epigrams and in the graceful witty epistle, and had a very considerable influence, as advance-guard of the 'Pléiade.'

In 1548, the chance meeting of two young poets, Pierre de Ronsard (1524–85) and Joachim du Bellay (1522–60), led to the foundation of a new group, called 'La Pléiade' because at first, like the stars of that constellation, they were seven, the remaining five being Jean Daurat, Jean Antoine de Baïf, Rémy Belleau, Etienne Jodelle and Pontus de Thyard.

In their freshness of thought, their exquisite art and their haunting music, the Pléiade represent the finest achievement of the French Renaissance. Du Bellay's notable treatise, 'Défense et Illustration de la Langue française,' advocates, in combination with the development of the mother-tongue, a cult of antiquity; instead of the medieval ballades and chansons, he urged the imitation of classic forms and of the sonnet, newly evolved in Italy.

Ronsard himself is one of the outstanding poets in French literature; indeed, his lyrics, his elegies and his sonnets rank with the loveliest ever produced in any country.

Most famous, from his 'Sonnets pour Hélène,' is that which begins:

> Quand vous serez bien vieille, au soir, à la chandelle,
> Assise auprès du feu, dévidant et filant,
> Direz, chantant mes vers et vous émerveillant,
> Ronsard me célébrait du temps que j'étais belle . . .

Memorable, too, are many of Du Bellay's poems, notably the sonnet, Petrarchan in spirit and in form, which begins:

> Si notre vie est moins qu'une journée
> En l'éternel, si l'an qui fait le tour
> Chasse nos jours sans espoir de retour,
> Si périssable est toute chose née . . .

and the beautiful

> Heureux qui comme Ulysse a fait un beau voyage . . .

Andrew Lang, in his 'Ballads and Lyrics of Old France' and 'Ballades of Blue China,' translated some of the work of these two poets, and of others, dating back to the time of Villon.

Malherbe. The period concludes with a famous writer—François Malherbe (1555–1628), who laid it down that the realm of literature should be obedient to rules. Archaisms, technical terms, dialect forms and low expressions were excluded from the poetic vocabulary; and Malherbe insisted on exact rhymes and measures, and condemned inversions and elliptical forms in syntax. This tended to make verse mechanical; it clarified the sense but impaired the spontaneity.

From Malherbe and his period we date the beginnings of those characteristics for which French literature became so highly esteemed throughout the world. First, scrupulous exactitude in the use of language; lucidity, precision, economy—these were the aim. Secondly the appeal to reason; abstractions, sentimentality and illusions, bad logic and distractions from the main argument must all be avoided. Thirdly, the greatest French authors have been close observers of human nature, usually in a spirit of tolerance, even of pity.

LESSON TWO

French II: The Golden Age

The 17th century, or Classical Period, can be called the Golden Age of French literature. The growing esteem in which literature was held is shown by two developments which were to have an incalculable influence: first, the 'salon,' and second, the French Academy.

The Salon. The literary 'salon,' or drawing-room, preluded the Golden Age and has continued, in varying fashion, up to our own times. It began when the Marchioness de Rambouillet (1588–1665), a rich, cultured woman of Italian birth, opened the doors of her great house in Paris to men of letters. Her salon was their meeting-place for the first half of the century, and attracted the best minds of the age. There they could exchange ideas in a pleasant atmosphere, and many a young author received encouragement. Later the salon deteriorated, becoming the haunt of the affected women whom Molière was to expose in 'Les Précieuses Ridicules' and 'Les Femmes Savantes.' 'Préciosité,' in its insistence on elegance and refinement, paved the way for Classicism.

Mme. de Rambouillet's example was followed by many other leaders of society. Valentin Conrart, a secretary to the king, used to receive once a week a distinguished gathering of men of letters, old and young, who read aloud their new works and discussed them freely. News of these meetings reached the great Cardinal Richelieu, the 'power behind the throne,' in the year 1629. That far-seeing man thought: 'Why should we not have a sort of central salon, where all the groups can meet? Why not create an official body that will make a duty of conserving our language and encouraging the best that there is in literature?' And so the French Academy was founded, and held its first formal sitting in 1635.

The French Academy. The Academy largely succeeded in establishing the form of French literature. From then onwards the French author came under its invisible discipline; as it was an association of the literary élite, not of dry scholastic pedagogues, and as he might one day be honoured by membership, he respected its judgements. The Academy recruited itself by election; there have usually been some forty members. In a robust spirit it undertook the vigilance and encouragement of literature. It has been the background of French letters since the day of its foundation, and its awards are among the most coveted literary distinctions.

Under the chairmanship and supervision of a member named Chapelain, a Dictionary of the Academy was prepared. The first edition of this authoritative work appeared in 1694; it was revised in succeeding centuries and the present eighth edition is the stand-by of contemporary French authors.

Boileau. That literature took its classical mould was largely due to the labours of Nicolas Boileau (1636–1711), who has been called 'the lawgiver of Parnassus.' Boileau, like Malherbe, advocated strict regularity and decorousness in poetry, and he urged the wisdom of being guided by the Greek and Latin classics. His own output was, on the whole, undistinguished, and it is as a literary critic that he is important; his 'Art Poétique' (1674) was, indeed, a landmark.

***TWO GREAT CLASSIC DRAMATISTS.** Corneille and Racine were the outstanding representatives of French classical drama, which began with Corneille's 'Le Cid.' The portrait of Corneille (left) is from the Bibliothèque de la Comédie française; that of Racine (right) is from an engraving by G. Edelinck.*

It is true that the great masterpieces of the age had already been written, but Boileau, who enjoyed the favour of Louis XIV, the friendship of Racine, Molière and La Fontaine, and the leadership of the French Academy, had undoubtedly encouraged his contemporaries to follow their bent towards classicism, and he set the seal of critical approval upon their work. In England, 'L'Art Poétique' was the model for Pope's 'Essay on Criticism,' and its precepts had a profound effect.

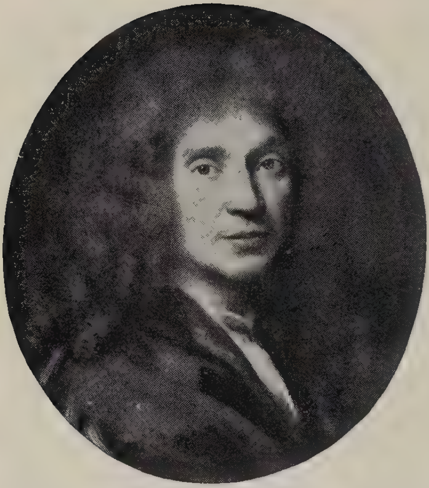
Drama in the 17th Century. The Classic Period reached its finest flowering in drama. Pierre Corneille (1606–84) was the first great French dramatist; before him, the theatre was poor and backward in comparison with that of England. Corneille found tragedy in the conflict between strong wills and untoward circumstance. History attracted him, because it provided the strong-willed personages suitable for his purpose. He was the first French dramatist to frame his plays within the classic unities of time, place and action (*see* Drama, Vol. II, p. 10). They are in verse of unsurpassed eloquence, the measure being rhymed alexandrines.

'Le Cid' (1636) is an outstanding event in French drama; it had an immediate success. Corneille had studied Spanish drama, and his work, in its nobility of theme and treatment, shows the influence of Calderón; this particular play is based on the 'Mocedades del Cid' (Youthful Exploits of the Cid), by Guillén de Castro. 'Horace,' 'Cinna' and 'Polyeucte' are the best known of Corneille's other tragedies; he wrote eighteen, of which twelve are based on Roman history. He also gave the French stage its best comedy before Molière—'Le Menteur.'

Molière. We now come to the greatest figure in French literature, the one man who ranks with Dante, Shakespeare, Cervantes and Goethe. Molière, whose real name was Jean-Baptiste Poquelin (1622–73), came of worthy bourgeois stock. The theatre had an irresistible attraction for him; he changed his name and became an actor in a travelling company, where he had twelve years of hard apprenticeship. Like Shakespeare, he helped to furbish up old plays and then, happily for mankind, was tempted to try his hand at original composition.

The genius of Molière is essentially French. Breaking completely away from the existing classical conventions, he sought out old French tales, old farces, old episodes in the national repertory; some of these were based on the Italian 'commedia dell' arte.' From them he improvised his plays with the aid of the company, often playing the part of leading man himself.

In this seemingly haphazard fashion, Molière evolved some thirty comedies. His masterpieces are: 'Les Précieuses Ridicules,' 'L'Ecole des Femmes,' 'Tartuffe,' 'Le Misanthrope,' 'L'Avare,' 'Le Bourgeois



MOLIÈRE. *The genius of French drama, Molière broke away from classic influences and wrote excellent comedies, some thirty in all, which reflect the life and manners of his own times.*

P. Mignard, Musée Condé, Chantilly; photo, Giraudon

Gentilhomme,' 'Les Femmes Savantes,' 'Le Malade Imaginaire,' 'Le Médecin Malgré Lui.' All his plays, even those with a touch of tragedy, have a very hearty wit and gaiety and are obviously the work of a man who knew perfectly how to captivate his audience. His high moral purpose is never obtrusive. Goethe pays him this tribute:

> I read some of Molière's comedies every year, just as from time to time I contemplate the engravings of the great Italian masters. For we little men are not able to retain the greatness of such things within us.

Of Molière's immediate successors in comedy, the most important was Jean François Regnard, who also thoroughly understood how to amuse his audience.

Racine. No dramatist differs more from Molière in temperament and in works than Jean Racine (1639–99), who continued the classical traditions of the theatre, resembling Corneille in style and presentation. Racine was an aesthete, a select seminary product, under the influence of the Jesuits of Port-Royal, who were known as Jansenists; Molière was a 'bon vivant.' Racine based his work on Greek tragedy, mostly Euripides; Molière was essentially French and evolved his own drama.

Racine, however, is a masterly dramatist whose plays are excellent theatre. They move rapidly and logically from beginning to end with the relentlessness of Greek drama. His masterpieces are 'Andromaque,' 'Britannicus,' 'Bérénice,' 'Iphigénie,' 'Phèdre,' and finally his two Biblical plays 'Esther' and 'Athalie.' The music of his verse is a limpid medium for ideas and can be a gentle caress to the senses.

La Fontaine. Lyric poetry is absent from this period; the effect of 'L'Art Poétique' had been to curb spontaneity. But we have the genius of Jean de La Fontaine (1621–95), whose truly delightful 'Fables' are based on Aesop and other sources, the moral being succinctly stated at the end of each. La Fontaine uses an infinite variety of rhythm in his easy-flowing verse, and his rhymes are witty and ingenious.

Fairy Tales. This same period saw the fairy tale taking literary form. Charles Perrault (1628–1703) published his 'Contes du Temps Passé' in 1697, creating the Sleeping Beauty, Cinderella, Little Red Riding Hood, Blue Beard, Puss in Boots, Tom Thumb and Riquet with the Tuft. Madame d'Aulnoy and other writers followed; and at the end of the following century a vast collection was made, in 40 volumes, entitled 'Le Cabinet des Fées.'

Early Novels. The novel was beginning to emerge. Charles Sorel's lively 'Vraie Histoire Comique de Francion' (12 volumes, 1622–41) was influenced by the picaresque novel which began in Spain in 1554; Paul Scarron's 'Roman Comique' (1651–57) is in the same vein. There were also a number of lengthy and far-fetched romances with a pseudo-historical background; Mlle. Madeleine de Scudéry, one of the 'précieuses ridicules,' produced many of these, notably 'Le Grand

LA FONTAINE. *This witty fabulist took many of his stories from Aesop, turning them into graceful verse of infinite variety and pointing the moral.*

After the painting by Rigaud

Cyrus' (10 vols.) and 'Clélie' (8 vols.). About thirty years later, we have the first novel of psychological interest, Madame de Lafayette's tender romance of 'La Princesse de Clèves' (1678).

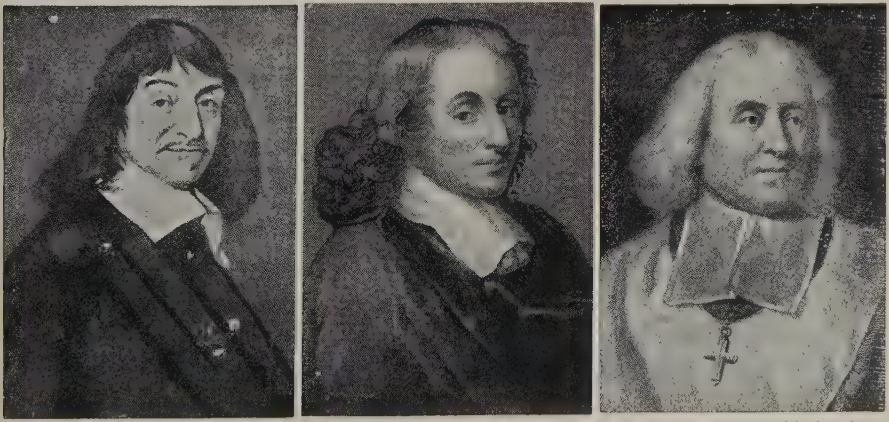
This lady was the friend of Madame de Sévigné (1626–96), in whose thoroughly entertaining Letters, some 1,500 in all, the age of Louis XIV lives before us. Madame de Sévigné was of noble birth, well-educated but no blue-stocking; she enjoyed with equal zest the gay superficialities of court society and the quiet pleasures of the country.

MADAME DE SÉVIGNÉ. A delightful letter-writer, this lady depicted the gay life of the court and the rustic pleasures of her country home. She won fame without seeking it.

Descartes. In more serious vein, the Golden Age gave us the great philosopher Descartes and many notable moralists, preachers and prose-writers. René Descartes (1596–1650), by his 'Discours de la Méthode,' influenced French thought up to the middle of the 19th century. The Cartesian Method applied mathematics to philosophy (*see* Philosophy, Vol. V., Lesson 6), and its exaltation of reason appealed so strongly to the French mentality that authors began to adopt it in addition to the strictly literary principles inculcated by Malherbe and Boileau. Descartes wrote with the lucidity which had become an essential feature of French prose.

Pascal. Of the moralists, Blaise Pascal (1623–62) was first to present his thoughts in concentrated form. The 'Pensées' of Pascal have an eternal appeal, for they are the attempt of a very fine mind to convince the sceptical or indifferent of the necessity for religion, and they are written in a pellucid style, with an energetic and orderly progression, at times touching high peaks of inspiration and majesty. Pascal was a distinguished mathematician who owed his spiritual development to the Jansenists. His 'Lettres écrites à un Provincial,' a defence of Jansenism, is a great dialectic work, achieving its effect by superb irony.

La Rochefoucauld. Contemporary with Pascal was the Duke of La Rochefoucauld (1613–80), whose volume of 700 brilliant 'Maximes' is as famous as the work of Pascal. La Rochefoucauld sees in self-interest the mainspring of all human conduct and behaviour. To him, if we do a good turn, we never do it disinterestedly; in final analysis, we do it to give pleasure to our-



MASTERS OF FRENCH PROSE. The influence of the great French philosopher, Descartes (left), has been incalculable. He evolved the Cartesian method, which made Reason the touchstone. In logic and lucidity, he is matched by Pascal (centre), author of the famous 'Pensées.' Bossuet (right) was, in his sermons and funeral orations, the noblest orator of his age.

Portrait of Descartes, the Louvre (photo, Giraudon); Pascal by Philippe de Champagne in the possession of M. Lenoir of Paris (photo, E.N.A.)

***FÉNELON.** A penetrating thinker, Fénelon, archbishop of Cambrai, did not hesitate to express his criticism of established institutions. He advocated the higher education of girls.*

Bust by Lenoir, The Louvre (photo, Giraudon)

selves; but he saves himself from the charge of cynicism by declaring that his ' Maximes ' are based on his own experience of a corrupt society, and must not be applied to those who have the advantages of Divine Grace. La Rochefoucauld's aphorisms are written in a lapidary style, each word having its narrow, precise meaning.

Bossuet. The finest preacher of his age was Jacques Bénigne Bossuet (1627–1704), whose sermons attracted so much notice that in 1669 he was appointed tutor to the Dauphin (Louis XIV's son), and afterwards became Bishop of Meaux. He delivered funeral orations on the leading personalities of the day, and these, with his sermons, are superb examples of French prose, lit with imaginative fervour.

Famous Prose-writers. The period closes with three important prose-writers: La Bruyère, Fénelon and Saint-Simon.

Jean de la Bruyère (1645–96) translated the ' Characters ' of the Greek Theophrastus, adding his own original work, which at first occupied one third of the book but was enlarged in successive editions. He owed much to La Rochefoucauld's ' Maximes,' which determined the form of his earlier jottings; later he added characters, or satiric portraits, such as were popular at the period. Though not a profound thinker, he is a master of style, and the ' Caractères,' published in 1688, won instant popularity.

Much more interesting in his ideas, but comparatively dull in style, was François Salignac de la Mothe Fénelon (1651–1715), an outspoken critic of the King and government; his Utopian ' Télémaque ' is one of the earliest portents of the still distant French Revolution.

Louis, Duke of Saint-Simon (1675–1755), gave posterity in his ' Mémoires ' a vivid, though not impartial, picture of the times, written in a nervous, brilliantly imaginative style.

The 17th century had seen classicism, which conformed to tradition and authority, gradually displaced by a new spirit of criticism, which questioned the validity of tradition and authority and encouraged the growth of individualism. We pass now into the Age of Enlightenment.

LESSON THREE

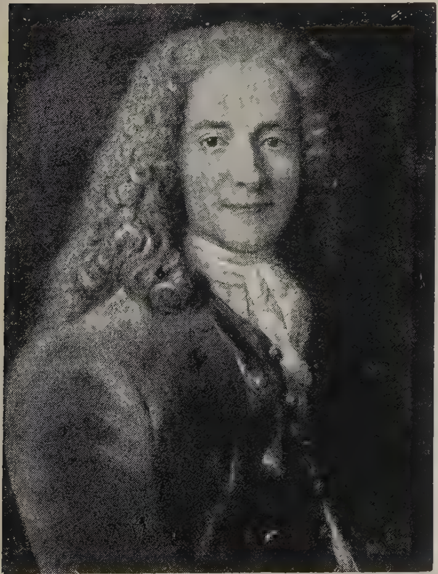
French III: The Age of Enlightenment

THE 18th century has been called the Age of Enlightenment. It was an age of free thought and new ideas; it criticized the existing traditions and authorities with penetrating logic and devastating wit, resolute to destroy in order that the ground might be cleared for reconstruction.

In France there were three outstanding writers whose thought had profound effects upon the political and social history of Europe—indeed, of the world. These three canalized the impetus of the movement which burst on the world as the French Revolution in 1789. They were Montesquieu (1689–1755); Voltaire (1694–1778); and Rousseau (1712–78).

Montesquieu. Charles-Louis de Secondat, Baron de Montesquieu, was an aristocrat who, from his earliest days, showed a profound intellectual honesty. He would take an idea, analyse it, regard it from every angle, and give his conclusions, however unpalatable they might be. He wrote, for the entertainment of himself and others, the delightful 'Lettres Persanes,' purporting to be the letters of a cultured Persian gentleman residing in Paris, who wished to convey to his friends at home his ideas of French society and of representative characters. In another work he examined Roman civilization and gave his reasons for its decline, forestalling many of the ideas of Gibbon. But it is his 'L'Esprit des Lois' (1748) which most influenced history.

In 'L'Esprit des Lois' Montesquieu sets forth the results of his life study of the conduct of men, and how best they should order their affairs. This book may be called a treatise on political science; it was also the Bible of Liberalism. The author hoped to save the decadent monarchy by pointing to the success of the English monarchy, and the reasons for it. He was too late. Already there was revolution in the air. Montesquieu's book created a method, a dialectic, crystallizing a host of progressive ideas which others had treated vaguely or not at all. It was denounced by authority and put on the Index of forbidden books by the Church. But in less than two years a score of editions had appeared. The doctrines of Liberalism had been clarified and defined. Montesquieu put the finishing touch to the political ideas of the men who were to lead the Revolution. He gave them that code which was to be their most formidable weapon. The theory and practice of 'Liberty, Equality, Fraternity' were defined by Montesquieu.



VOLTAIRE. From his château at Ferney, Voltaire castigated the abuses of the time. Here he is seen in his prime, when he was the guest of royalties. See other portraits in our Courses on Social History (Vol. III, p. 82) and Art (Vol. I, p. 62).

Voltaire. François-Marie Arouet, who took the pen-name of Voltaire, was the greatest literary figure in Europe during most of the 18th century. He is one of the prodigies of all literature, expressing himself with facility in drama, poetry, novels, short stories, literary criticism, history, political and didactic pamphlets, and philosophical treatises.

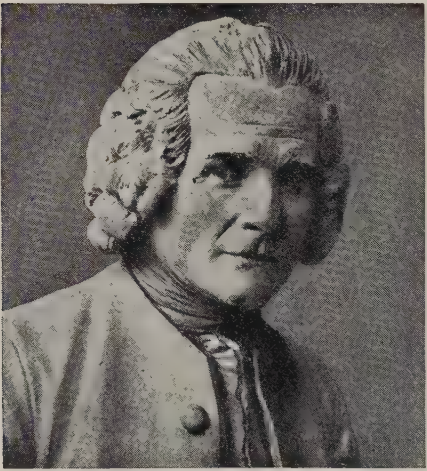
His works comprise some fifty plays, the best being his tragedies 'Mérope' and 'Zaïre'; a vast output of poems, including the epic 'Henriade,' the scurrilous 'La Pucelle,' the philosophic 'Discours sur l'Homme'—which owed something to Pope's 'Essay on Man'—and graceful light verse of various kinds; prose tales, of which the brilliant 'Candide' and 'Zadig' have become familiar in translations all over the world; the 'Commentaire sur Corneille,' which shows him to be a classicist under the influence of Boileau; histories, notably 'Charles XII,' 'Siècle de Louis XIV' and 'Essai sur les Moeurs' (an attack on tyranny), which contain a wealth of valuable material and are also very readable; political treatises, such as the 'Lettres anglaises' in which he praised British institutions and ways of thought at the expense of the French; discussions of philosophy, such as the 'Essai sur la Philosophie de Newton' and the trenchant 'Dictionaire Philosophique'; and a voluminous correspondence, some 10,000 letters in all, which make fascinating reading, for Voltaire was in close touch with the most interesting personalities throughout Europe, including Frederick the Great and Catherine the Great.

He writes always in sparkling and impeccable prose, so simple that it can be read with ease by the foreigner who has studied the language for a few months only, and never dull.

Voltaire's earliest efforts made him immediately famous, though one of them, a plea for religious toleration, caused his imprisonment in the Bastille. He did not mince words and, in an age when the Church was all-powerful, he set about attacking it with vigour and brilliance and continued this attack throughout his long life. There were then in France some 400,000 clergy, monks, nuns and Church retainers, with possessions estimated at £2,000 millions and an annual revenue of £140 millions. They were free of taxation; the higher members of the Church had all the privileges of the nobility. It was this unhealthy state of affairs which Voltaire attacked: a too worldly clericalism rather than the fundamentals of religion. 'Ecrasez l'Infame'—'Crush the infamous!'—this was his slogan (*see* Social History Vol. III, Lesson 19).

He had to seek refuge in Switzerland, whence, first from Délices and later from Ferney, his influence on French and European thought elevated him to a status greater than that of most royalty. The works of this extraordinary man, more than those of any one writer, prepared the way for the political and social upheaval of the Revolution.

Rousseau and the 'Social Contract.' In Jean-Jacques Rousseau we find an altogether different writer. He was born in Geneva, brought up in Switzerland, and for a period during his youth was converted to Catholicism. For many years Rousseau did humble work in order to live; much of his life was sheer vagabondage, and he did not move in cultured circles until well advanced in years. 'Le Rétablissement des Sciences et des Arts,' an indictment of civilization, was crowned by the Academy of Dijon. 'Emile' suggested a system of education based on a return to Nature rather than on books. 'La Nouvelle Héloïse' is a novel advocating the reform of marriage.



ROUSSEAU. ***The Romantic Revival throughout Europe owes much to Rousseau, who with moving eloquence preached social reform through a return to Nature. Houdon's bust was based on his death-mask.***

Musée Jacquemart-André, Paris

In 1762 appeared Rousseau's 'Contrat Social,' a remarkable book that is responsible for much European thought and contained the germs of the American and French Republics. It propounds the argument that 'The voice of the people is the voice of God'; this, with its insistence on equality and the sovereignty of the people, is the central idea of Rousseau's system. As Voltaire had been the apostle of toleration and liberty, so Rousseau was the apostle of equality and fraternity.

As a writer, Rousseau is somewhat uneven; he is often loose in his construction, and has not always that clarity which we regard as an essential of the good French writer. But in one respect he surpasses all his contemporaries—eloquence. It was always far more moving to hear a reading from Rousseau than from any of his contemporaries.

In his 'Confessions,' a strange, frank autobiography which is now his most widely read book, we see him as the forefather of the European Romantic movement, with its passionate individualism, its love of nature, its mystic apprehension of religious truths.

A disciple of Rousseau, Bernardin de Saint-Pierre (1737–1814) wrote the lovely idyll, 'Paul et Virginie.'

Diderot and the Encyclopédie. The fame of Denis Diderot (1713–84) has been eclipsed by the greater glory of Voltaire, but their contemporaries regarded Diderot as the profounder thinker, the true 'philosophe,' and many critics have agreed with their verdict. Diderot's output was as immense as Voltaire's and his range of interests was even wider; he kept up a constant flow of new ideas, expressed in lucid and stimulating style. Nevertheless he produced no masterpiece. He is remembered chiefly for that tremendous undertaking, the 'Encyclopédie' (1750–77), which ran to 34 volumes, of which Diderot was the principal editor. (For illustrations from it *see* Social History, Vol. III, p. 80).

The 'Encyclopédie' was originally intended to be a translation of Chambers' Encyclopedia (1727), but it was soon realized that such a production might have an incalculable effect in moulding popular thought, and the project was therefore modified so as not merely to summarize all existing knowledge but to destroy such conceptions as could not be justified by reason. Among its contributors were Montesquieu, Voltaire, Rousseau and Diderot himself, the distinguished philosopher and mathematician d'Alembert (1717–83), and Marmontel (1723–99), a novelist, dramatist and historian.

Another monumental work was produced single-handed by the Comte de Buffon (1707–88), a great naturalist, whose 'Histoire Naturelle' (1749–89) ran to 36 volumes, written in majestic style.

Drama and Novels. In drama, we have the witty sentimental comedies of Marivaux (1688–1763), of which the most popular are 'Le Jeu de l'Amour et du Hasard,' 'Le Legs' and 'L'Epreuve.' Beaumarchais (1732–99) was author of the delightful 'Barbier de Séville' and 'Mariage de Figaro.' Le Sage, better known as a novelist, wrote an excellent comedy, 'Turcaret.'

Marivaux was also a novelist, excelling in psychological interest; his 'Vie de Marianne' and 'Le Paysan Parvenu' deal with middle-class life in Paris. More important is Alain René Le Sage (1668–1747), whose 'Diable Boiteux' and 'Gil Blas' are gaily picaresque in the Spanish manner. The first novel of passion was the world-famous 'Manon Lescaut,' by the Abbé Prévost (1697–1763).

There was little poetry in this age of reason, but a revival of interest in Greek, due to archaeological discoveries, prepared the way for André Chénier (1762–94), a genius who has been compared with Keats. Chénier re-created the beauty of Greek antiquity; he also wrote impassioned satires against the Terrorists and was guillotined by them.

The turn of the century brought the Romantic Revival.

LESSON FOUR

French IV: Romantics and Realists

The first half of the 19th century saw, throughout Europe, the Romantic Revival. By 'Romantic' we mean the personal and subjective, deriving from feeling and observation rather than from any rules, and finding expression in a preference for picturesqueness and grandeur, passion, natural beauty and spontaneity, rather than in the accurate, formal and well-proportioned. In the work of the Romantic writer form is subordinated to matter; the whole is more important than the parts.

Early Romantics. Mme. de Staël (1766–1817) and François René, Vicomte de Chateaubriand (1768–1848), were heralds of the Romantic Movement in France, of which Rousseau had given the first hints. Mme. de Staël's 'De l'Allemagne' was an interpretation of the literature and national characteristics of Germany. The Germany of poets and philosophers, the Germany of enthusiasm and sense of wonder — those essentially Romantic qualities — is warmly commended.

Chateaubriand, in a series of romances, 'Atala,' 'René,' 'Les Natchez,' found poetry in the human heart, with its capacity for love and for renunciation. There is an undercurrent of religious fervour in his work. The range of his ideas is not great, but he showed himself to be possessed of wonderful descriptive powers and a romantic melancholy that was characteristic of the early years of the new century. His greatest work, 'Le Génie du Christianisme,' written after his conversion to Roman Catholicism, had a profound influence.

MADAME DE STAËL. A cosmopolitan and a leading figure in society, Madame de Staël by her critical expositions did much to inaugurate Romanticism. Her novels were the first to deal with the 'misunderstood' woman.

After P. L. Bourier

Romantic Poetry. Greatest of the Romantic poets were Alphonse de Lamartine (1790–1869), Alfred, Comte de Vigny (1797–1863), the prolific Victor Hugo (1802–85), and Alfred de Musset (1810–57).

Lamartine's 'Méditations Poétiques' (1820) had a sensational success; these incomparable lyrics revealed the beauty that lies in everyday scenes, as in 'Le Lac,' 'Le Vallon' and 'L'Automne.' Lamartine had the rare gift of invoking the poetic mood; nature, as he saw it, was a sympathetic background; he expressed the ideal love of Plato and

Petrarch, which outlives death; and death itself had no terrors for him. He published several collections of verse, together with the majestic epics 'Jocelyn' and 'La Chute d'un Ange,' and also wrote autobiographical novels and historical works.

De Vigny is a poet who stands apart, deeply pessimistic; he is oppressed by the miseries of mankind, the spiritual isolation of genius, the unresponsiveness of nature and the imminence of death, which to him means oblivion. He expressed his ideas symbolically in such masterpieces as 'Moïse,' 'La Mort du Loup,' 'Le Mont des Oliviers' and 'La Bouteille au Mer.' Man is urged to meet his destiny with fortitude, like the wolf in 'La Mort du Loup':

> Gémir, pleurer, prier, est également lâche.
> Fais énergiquement ta longue et lourde tâche
> Dans la voie où le Sort a voulu t'appeler.
> Puis après, comme moi, souffre et meurs sans
>   parler.

One of the loveliest of De Vigny's poems has no inner meaning—'Le Cor,' which invokes the spirit of Roland at Roncevaux.

***CHATEAUBRIAND.** An early Romantic, Chateaubriand wrote beautiful prose romances imbued with religious feeling; his influence was very great. In his youth he was a revolutionary, but reaction set in with the excesses of the Terror. He spent several years in England.*

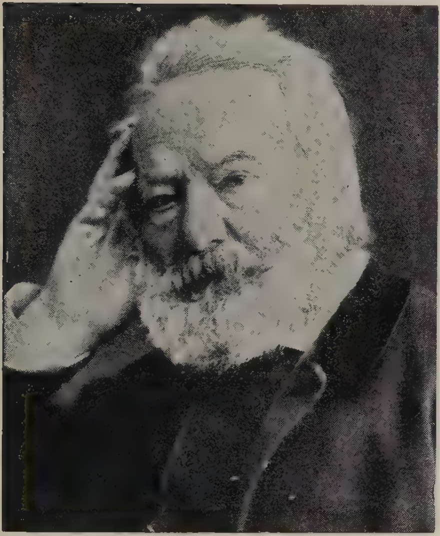
The whole of his poetry is contained in 'Poèmes anciens et modernes' (1826) and the posthumous 'Les Destinées.'

Alike in poetry, drama and prose, the masterly works of Victor Hugo dominate half the century. In him, a great imagination was wedded to a vast energy and industry. He wrote with extraordinary facility and virtuosity on subjects which appeal to the average man; the amount of his output is amazing, and its artistry is unfailing.

The early 'Odes' (1822), 'Nouvelles Odes' (1824) and 'Odes et Ballades' (1826) show characteristics which were to remain with Hugo throughout: the serious conception of his own calling as a poet, the intensely personal revelation of his feelings and ideas, the love of children, the hero-worship of Napoleon. 'Les Orientales' (1829) glowingly depicts the romance of the East, developing, in such poems as 'Les Djinns,' his superb rhythmical powers. Other volumes of lyrical verse were 'Les Feuilles d'Automne,' 'Les Chants du Crépuscule,' 'Les Voix Intérieures,' 'Les

***THREE ROMANTIC POETS.** These fine poets reflect various facets of the Romantic Movement. Lamartine (left), a fervent idealist, wrote of nature, revealing its beauties. De Vigny (centre), profoundly pessimistic, exalted the virtue of fortitude; many of his poems are symbolic. The more personal note is struck by De Musset (right), whose musical verse, limited in range and quantity but exquisite in detail, flows from a passionate heart. De Musset was also a delightful dramatist.*

Photo centre, E.N.A.; right, portrait of De Musset by Laudrelle, The Louvre (photo, Giraudon)



HUGO. The towering figure of his century, Victor Hugo wrote poetry, plays and novels with equal facility; his output was tremendous. His magnificent Romantic poetry has a wide range of subject and metre; his mighty novels have an epic sweep.

Rayons et les Ombres,' 'Les Châtiments' (a furious satirical attack on Louis Napoleon), and, most magnificent of all, 'Les Contemplations' (1856). 'La Légende des Siècles' is a sequence of brilliant visions illustrating the march of humanity through the ages; its most impressive scenes are 'Booz Endormi,' 'L'Aigle du Casque,' 'Le Satyre,' 'La Rose de l'Infante,' and 'Les Pauvres Gens.' Later collections were 'Chansons des Rues et des Bois,' 'L'Art d'être Grandpère,' 'Les Quatre Vents de l'Esprit' and 'Toute la Lyre.'

The poetry of Alfred de Musset consists of only two volumes, his 'Premières Poésies' and 'Poésies Nouvelles.' The first was written under the influence of Byron; the second followed his unhappy love affair with George Sand, of which he gives a deeply introspective study in the four 'Nuits' ('Nuit de Mai,' 'Nuit de Décembre,' 'Nuit d'Août,' 'Nuit d'Octobre'). De Musset's range is limited, but he is passionately sincere and capable of very beautiful and musical verse.

An interesting minor poet was Pierre Jean de Béranger (1780–1857), whose volumes of 'Chansons,' satirical verse for the man in the street, were extremely popular. He has been called the French Burns.

Romantic Drama. Drama, during the early part of the 19th century, was mainly historical, under the influence of foreign playwrights such as Schiller, or melodramatic. The Romantic Revival swept away the lingering conventions of classicism. Victor Hugo's preface to his play 'Cromwell' sets forth his ideas; tragedy and comedy should, he argued, be mingled as they are in real life, the unities should be disregarded as cramping, and local colour should be lavishly introduced. These were not new ideas, but Hugo's concise statement came as a landmark (1827).

'Cromwell,' however, was not intended for the stage; it has no fewer than 75 scenes and a host of characters. Hugo's later plays—'Hernani,' 'Marion Delorme,' 'Le Roi s'amuse,' 'Ruy Blas,' 'Les Burgraves'—contain much beautiful poetry, and the prose 'Lucrèce Borgia,' 'Marie Tudor' and 'Angelo' are undeniably exciting, but they are unreal. Hugo lacked the power of characterization; he simply manipulated the puppets of melodrama.

In this genre the first drama to be performed was 'Henri III et son Cour,' by Alexandre Dumas, which, though lacking in literary qualities, made a good lively stage-play and was followed by others. De Vigny, in 'Chatterton,' gave a fascinating psychological study of disappointed genius; De Musset excelled in delightful

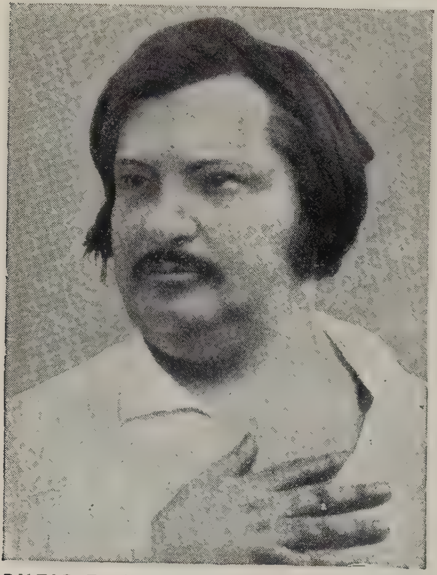
DUMAS. The prodigal virility of Alexandre Dumas was shown in his vast output of historical novels and plays, which had tremendous success and retain popularity. His son, too, was a celebrated playwright, author of 'La Dame aux Camélias.'

love-comedies, such as 'On ne badine pas avec l'amour,' 'Il faut qu'une porte soit ouverte ou fermée' and 'Il ne faut jurer de rien.'

Romantic Novels. The novel was now developing rapidly in France and it should be noted that the influence of Sir Walter Scott was paramount in the historical novel. It is as a novelist that Victor Hugo is most widely read. Outstanding among his works in fiction are 'Notre Dame de Paris' (1831), a colourful representation of the times of Louis XI, and 'Les Misérables' (1862), a tremendous panorama of life's tragi-comedy. Later came 'Les Travailleurs de la Mer' (1866) and 'Quatre-Vingt-Treize' (1874), which are also among the finest French novels. Hugo's narrative power is superb because of his imagination; his sense of the theatre enabled him to dramatize.

GEORGE SAND. After the failure of her marriage to a drunkard, Aurore Dupin made a career for herself as a sincere novelist, excelling in idyllic stories.

Alexandre Dumas (1802–70) wrote romantic adventure stories with a historical background; 'Les Trois Mousquetaires' and 'Le Comte de Monte Cristo' may be cited as typical examples from a vast output.



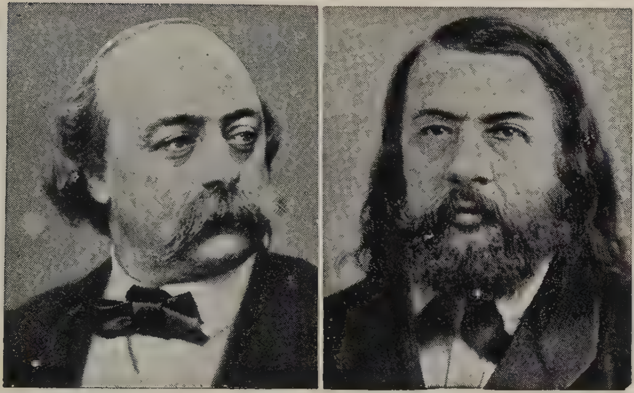
BALZAC. This is the only photograph of that dynamic genius, Honoré de Balzac, who was handicapped by poverty. Prodigiously industrious, he worked 12 to 16 hours a day and was the author of 85 novels.

The first psychological novels—'Le Rouge et le Noir' (1831) and 'La Chartreuse de Parme' (1839)—were written by Henri Beyle (1783–1842), whom we know as Stendhal. This type was derived from the sentimental romance, which originated with the medieval 'roman courtois,' but Stendhal's delicate analysis is entirely modern.

George Sand (1804–76), whose real name was Lucile-Aurore Dupin, at first wrote sentimental love-stories, the unhappiness of her own marriage finding expression in revolt against the tyranny of man. Later she produced humanitarian novels, but she was happiest in her idylls of country life, 'La Mare au Diable,' 'La Petite Fadette,' 'François le Champi' and 'Les Maîtres Sonneurs.' She was especially popular in Russia, where Dostoevski and Turgeniev were among those influenced by her.

Balzac. The greatest novelist of the period is Honoré de Balzac (1799–1850), whose 'Comédie Humaine' was based on the grandiose scheme of exhibiting every aspect and activity of human life. An exceptionally prolific writer, Balzac reproduced contemporary society with photographic accuracy of detail, in a style which is undistinguished but realistic. His plots are weak and his psychology is unconvincing, but he excels in vivid portraiture; Eugénie Grandet's miserly old father, and, at the other extreme, the over-indulgent Père Goriot, are striking examples. Of his many other novels, the best known are 'Les Chouans,' 'La Peau de Chagrin,' 'César Birotteau,' 'Le Cousin Pons,' 'La Cousine Bette,' and 'Le Médecin de Campagne.' Balzac also wrote short stories.

Gautier, Flaubert and Maupassant. Théophile Gautier (1811–72) is tremendously important; he expounded the doctrine 'Art for Art's sake,' which was accepted by most writers of the period, notably by Flaubert. Its meaning is that Art is independent of morality; perfection of form, irrespective of content, is to be its aim. Though pre-



GREAT LITERARY ARTISTS. It was Théophile Gautier (right) who, in his poetry and in his novels, first taught 'Art for Art's sake,' independently of other values. Gustave Flaubert (left), accepting this doctrine, excelled in realistic detail and, on occasion, in the glowing colour of his work.

eminently a poet, Gautier was the author of two notable novels, 'Mlle. de Maupin' and 'Le Capitaine Fracasse.' He also wrote excellent short stories, usually with an interest in the supernatural, as did Charles Nodier, Gérard de Nerval and Prosper Merimée (1803–70). The work of Merimée, notably 'Carmen,' is extraordinarily vivid.

In the second half of the 19th century, Gustave Flaubert (1821-80) is the outstanding novelist. 'Madame Bovary,' his first and most famous masterpiece, is the realistic story of a sentimental woman, married to a kind but dull husband. After a succession of love affairs she is faced with discovery and ruin, and poisons herself, dying hideously. From this sordid theme Flaubert's second masterpiece, 'Salammbô,' is altogether remote, its setting being Carthage after the First Punic War. So scrupulous in detail was the author of this colourful barbaric tale that he not only read every available authority but visited the region. Flaubert's power is revealed, too, in 'Un Coeur Simple,' the most moving of his 'Trois Contes.'

Flaubert's most important disciple was Guy de Maupassant (1850–93), who wrote numerous contes, some 300 in all, achieving success with his first, 'Boule de Suif.' He also produced several novels, sombre in theme, notably 'Une Vie' and 'Bel Ami.'

De Goncourts, Zola, Daudet. Edmond de Goncourt (1822–96) and his brother Jules (1830–70) wrote a series of impressionistic novels on morbid subjects in a nervous, over-refined style. Their Journal, with its stories of celebrities, is today regarded as their most interesting work.

It was Emile Zola (1840–1902) who evolved the theory of naturalism, which he discusses in 'Le Roman Expérimental.' His novels have a sociological purpose. The general effect is depressing, since, like the Goncourts, he was often preoccupied with pathological cases. The powerful 'Thérèse Raquin' owes much to 'Germinie Lacertieux,' the Goncourts' story of a servant's life.

In 1871 Zola began his great family-cycle, 'Les Rougon-Macquart: Histoire naturelle et sociale d'une famille sous le Second Empire.' The scheme was, no doubt, sug-

TWO GREAT NOVELISTS. Chief of the naturalistic novelists, Emile Zola (left) found an outlet for his sociological ideas in the great series known as 'Les Rougon-Macquart.' He was the undaunted champion of Dreyfus. Alphonse Daudet (right), a most delightful writer, has affinities with Dickens and Thackeray.

gested by Balzac's 'Comédie Humaine.' Zola intended to show various members of the family in their different settings, tracing the influence of heredity and environment and illustrating French civilization during this period. His family, however, are degenerates, and the picture is, therefore, a gloomy one. There are altogether 20 volumes (1871–93), of which the finest are 'L'Assommoir,' a shattering exposure of the evils of drink in working-class life; 'Germinal,' dealing with miners and the implications of a strike; 'La Bête Humaine,' in which the chief figure is a railwayman; and 'Le Débâcle,' describing the early part of the Franco-Prussian War. Afterwards Zola wrote the anti-clerical trilogy, 'Les Trois Villes' (Lourdes, Rome and Paris), and he had produced three parts of another sequence, 'Les Quatres Evangiles,' before he died. He wrote masterly short stories.

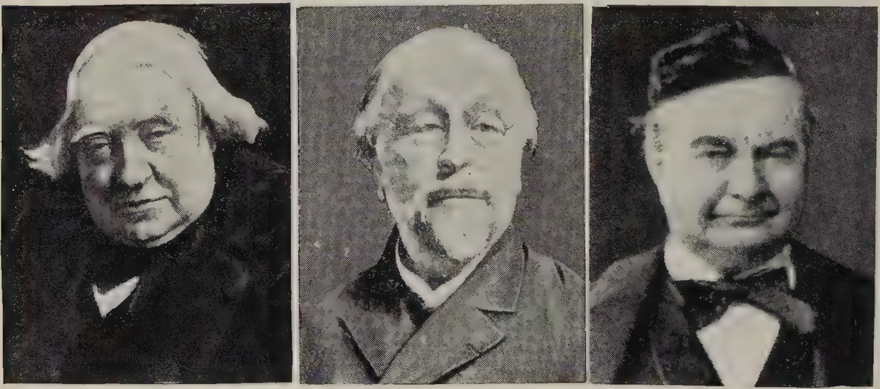
The naturalistic novels of Ferdinand Fabre (1830–98) deserve mention. His themes are chosen from clerical life; the most sympathetic is 'Mon Oncle Célestin.'

Last of the important novelists of the century is Alphonse Daudet (1840–97), whose most delightful work is in 'Le Petit Chose'—a largely autobiographical study of childhood and adolescence, showing the influence of Dickens—and two collections of short stories and sketches, 'Lettres de Mon Moulin' and 'Contes du Lundi.' The humorous 'Tartarin de Tarascon' and its sequels were most popular, and 'Fromont jeune et Risler aîné' and the pathetic 'Jack,' influenced by Thackeray and Dickens respectively, deserve to be remembered. 'Sapho,' a novel of passion, attracted attention and has been translated.

Historians and Critics. The century produced many fine historians. In the early period François Guizot (1787–1874) is preeminent. A great statesman, he found time to write many valuable histories, of which the 'Histoire de la Civilisation en Europe' and 'Histoire de la Civilisation en France' are famous. He was the first philosophical historian, and set an example for the brilliant François Mignet (1796–1884), author of a 'Histoire de la Révolution française,' and Adolphe Thiers (1797–1877), who wrote a much longer work under the same title. Alexis de Tocqueville (1805–59) did excellent work in the same field.

More romantic, in his love of picturesque detail, was Augustin Thierry (1795–1856); and the greatest of them all was Jules Michelet (1798–1874), whose monumental 'Histoire de France' runs to 27 volumes. He was the first to link geography with history and thus to see his subject whole.

In the later period we have three great prose writers, Ernest Renan (1823–92), Hippolyte Taine (1828–93) and Charles Augustin de Sainte-Beuve (1804–69). Renan is best known for his 'Vie de Jésus,' which raised a storm; it treated Christ as a human person of historical importance, refusing to accept the supernatural but retaining the moral



MASTERS OF PROSE. Renan (left) created a storm with his 'Life of Jesus,' a rationalistic interpretation, paying homage to the moral aspects of Christ's teaching but denying supernatural elements. Taine (centre), historian and literary critic, was a realist and a pessimist in his ideas, though he embodied them in rich romantic prose. Sainte-Beuve (right) is the literary critic par excellence, immensely erudite and possessed of an unfailing charm. He had the gift of appreciating personality and was quite unprejudiced.

Portrait of Renan by L. Bonnat

values of His life and teaching. This was merely the first volume of a great work, 'Les Origines du Christianisme,' to which he afterwards linked his 'Histoire du peuple d'Israel.' Renan's 'Souvenirs' are delightful.

Taine's chief historical work is 'Origines de la France contemporaine.' He is best known as a literary critic. Besides several volumes of essays and travel, he wrote a 5-volume history of English literature, and an important philosophical study, 'Théorie de l'Intelligence.'

Sainte-Beuve is supreme in literary criticism; he covered practically the whole field. For twenty years he wrote newspaper articles embodying a vast amount of research; they appeared on Mondays and were republished as the fascinating 'Causeries du Lundi' (15 vols.) and 'Nouveaux Lundis' (13 vols.). Another series was collected in various volumes of 'Portraits.'

The diplomat Jean Jusserand (1855–1932) wrote extensively, and his 'Histoire littéraire du peuple anglais' is a masterly treatise. Towards the end of the century, Rémy de Gourmont (1858–1915) set out to explain Symbolism.

The Parnassians. In poetry, the Romantics were followed by the Parnassian School, so called because they came into public notice through the publication of an anthology, 'Le Parnasse contemporain,' in 1866. They were influenced by Théophile Gautier, who had formulated the watchword, 'Art for Art's sake.' Gautier had been trained as an artist; shapeliness, colour and music are the characteristics of his verse, which is seen at its best in 'Emaux et Camées.' His chief disciple was Théodore de Banville (1823–91), a master of rhythm.

Of the Parnassians, Leconte de Lisle (1820–94) and José-Marie de Hérédia (1842–1905) were true poets, as well as superb artists. Both were born in the tropics, and this early background coloured their minds. Leconte de Lisle has the power of invoking remote civilizations with a glowing vitality which is accompanied by real insight. Hérédia wrote little; his sonnets, collected as 'Les Trophées,' are highly concentrated.

In the same group, but not in the same rank as poets, were René Sully-Prudhomme (1839–1907), much admired for the philosophic content of his work, and François Coppée (1842–1908), who excelled in everyday scenes of Parisian life and also in poetic drama.

Naturalism in Drama. At this period drama was realistic and mediocre. Eugène Scribe (1791–1861) turned out some 400 plays, which were sufficiently well constructed and suited the popular taste. Alexandre Dumas the younger (1824–95) produced a stage masterpiece, 'La Dame aux Camélias,' which his many other plays never equalled. Emile Augier (1826–89) wrote bourgeois plays, of which 'Le Gendre de M. Poirier' is outstanding. Victorien Sardou (1831–1908) achieved popularity in various forms of drama, and Henri Becque (1837–99) presented squalid scenes in which the realism was a challenge to contemporary artificiality.

LESSON FIVE

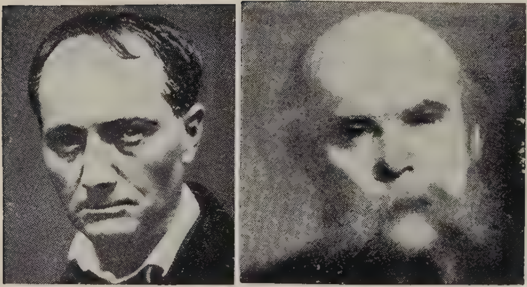
French V: Symbolism and the Moderns

We come now to the Symbolists, who believed that art should be suggestive rather than explicit. Their most important predecessor was Charles Baudelaire (1821–67), whose famous 'Fleurs du Mal' appeared in 1857. This is a study of decadence, containing passages of haunting beauty. Less well known are Baudelaire's exquisite 'Petits Poèmes en Prose,' which also had a considerable influence.

The Poets. Paul Verlaine (1844–96) and Stéphane Mallarmé (1842–98) were the leaders of the Symbolist school. Verlaine is, surely, the most melodious of French poets, the most suggestive, the most intimate. Such poems as 'Les sanglots longs des violons,' 'Il pleure dans mon coeur' and 'Lune blanche' are of the fabric of immortality, and the volume 'Sagesse' contains some of the noblest religious verse ever written. Like Villon, Verlaine led a squalid life, but his glory is undimmed.

Mallarmé lacked this lyric gift; he was an intellectual, self-consciously applying his theories. He uses words not in their literal sense but as evocative symbols, often disregarding syntax. 'L'Après-midi d'un Faune,' his finest poem, inspired the musical composition of the same name by Debussy.

A most interesting figure is Arthur Rimbaud (1854–91), who wrote all his poetry before the age of 19, and then quarrelled with his friend Verlaine and embarked on an adventurous life, eventually becoming an



SYMBOLIST POETS. Baudelaire (left), precursor of Symbolism, was a neurotic and led a dissipated life, as did that lyrical genius Verlaine (right). After attempting to kill his friend Rimbaud, Verlaine underwent religious conversion in prison.

Portrait of Verlaine by Eugène Carrière; The Louvre

influential trader in Abyssinia. Rimbaud's masterpieces are 'Le Bal des Pendus,' 'Bateau ivre' and the prose poems, 'Les Illuminations.' 'Une Saison en Enfer' records his spiritual development. Rimbaud is still one of the most modern of poets, and his influence has been very great. He is a poet of the depths and shadows of the soul, and there is in much of his work all the primitive savagery of the jungle. It is highly disconcerting poetry.

Of the many other Symbolist poets Albert Samain (1858–1900) and Henri de Régnier (1864–1936) are most important. Samain wrote little, but exquisitely. De Régnier was prolific and uniformly excellent, in verse and prose; he was a master of vers libre.

Charles Péguy (1873–1914), founder of the influential review, 'Cahiers de la Quinzaine,' wrote three mystic tributes to Joan of Arc, in the rhythmic prose of 'Les Illuminations,' and also wrote verse in regular Alexandrines. Francis Jammes (1868–1938) and Paul Fort (b. 1872) handled metre in an original way and expressed a love of nature and religion.

Emile Verhaeren (1855–1916) belongs to the modern movement rather than to Symbolism. A Belgian, he found inspiration in the industrial life of Flanders and the neighbouring French region; he was also a mystic.

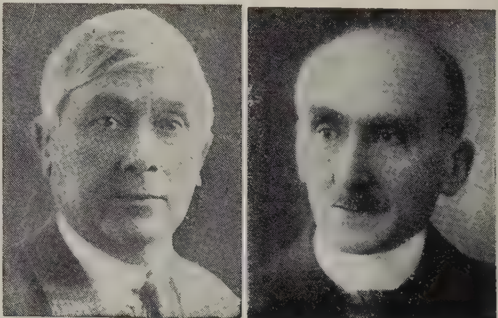
Symbolism on the Stage. In drama Count Villiers de l'Isle Adam (1840–89) preceded the Belgian Count Maurice Maeterlinck (b. 1862), whose plays, with their brooding sense of mystery, have become world-famous. Maeterlinck's masterpieces are 'Pelléas et Mélisande' (made into an opera by Debussy), and 'L'Oiseau Bleu,' a fairy play. He also wrote one-act plays, essays and studies from nature, such as 'La Vie des Abeilles.' Another Symbolist, Paul Claudel (b. 1868), won fame as a poet and wrote the lovely play, 'L'Annonce Faite à Marie.'

Bergson. Linked with Symbolism is the philosopher Henri Bergson (1859–1941), whose brilliant exposition of the part played by intuition and by the subconscious, though it came when the Symbolist movement was already in existence, could not fail to reinforce it. Bergson saw life as a continuous stream of energy to which every individual could contribute; his was a stimulating philosophy. It is set forth in such volumes as 'L'Evolution Créatrice,' 'L'Energie Spirituelle' and 'Durée et Simultanéité.' A fuller exposition is given in our Philosophy Course in this Volume, Lesson 14, pp. 176–77.

Symbolistic novels are rare; De Régnier wrote several, as did Maurice Barrès (1862–1923) before writing his regional novels. Georges Rodenbach (1855–98), a Belgian poet, wrote the symbolistic novel *par excellence* in 'Bruges-la-Morte.'

Great Modern Novelists. Towards the end of the century, the greatest novelists were Paul Bourget (1852–1935), Anatole France (1844–1924) and Pierre Loti (1850–1923).

Bourget, a scientist, produced many studies of contemporary morality, applying a keen psychological analysis. 'Cruelle Enigme,' 'Un Crime d'Amour,' 'André Cornélis.' 'Le Disciple,' 'Un Saint,' 'La



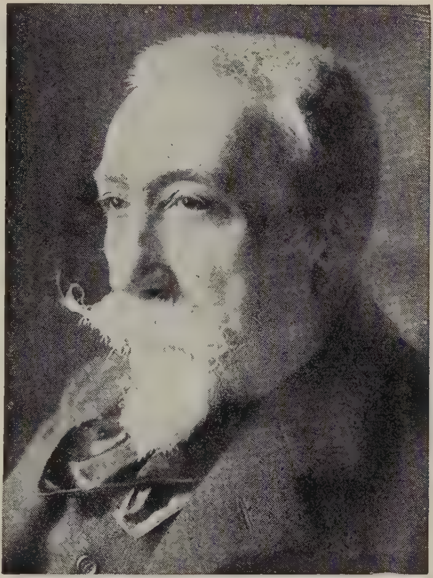
FAMOUS SYMBOLISTS. There is a strange nebulous beauty in the plays of Maurice Maeterlinck (left), a Belgian by birth, who received the Nobel Prize in 1911. The philosopher Bergson (right) has brilliantly expounded the hidden forces of the subconscious mind.

Photo, right, E.N.A.

Terre promise,' 'Outre-mer,' 'Un Idylle tragique,' 'Némésis,' 'Agnès Delas,' are characteristic of his very large output, which included short stories.

The greatest of modern French prose-writers, Anatole France (whose real name was Jacques Anatole Thibault) used the novel as a vehicle for his philosophical ideas, which he presented with consummate skill. His prodigious learning never overweighted his books, but, handled ironically, was an added charm. He writes with verve and grace, and often with a robust humour. Best known of his novels are the delightful 'Crime de Sylvestre Bonnard,' the Rabelaisian 'Rôtisserie de la Reine Pédauque,' the satirical 'Ile des Pingouins,' the colourful 'Thaïs,' the vivid 'Lys Rouge' and the powerful 'Crainquebille.' His 'Histoire contemporaine' is a sequence of four novels depicting the society of the day; 'Les Dieux ont Soif' and 'La Révolte des Anges' develop his political ideas. 'L'Etui de Nacre' is a volume of masterly short stories.

Pierre Loti was a naval officer whose real name was Julien Viaud. His novels are wonderful word-paintings, often with exotic settings, in which the sea plays an important part. 'Mon Frère Yves' and 'Pêcheur d'Islande' are stories of Brittany and seafaring folk, and 'Ramuntcho' deals with the Basque Country; these are his finest.



ANATOLE FRANCE. *Outstanding among modern French novelists was this grand old man, who in many excellent volumes showed the vigour and grace of his well-stocked and witty mind. He used the novel as a means of ironic exposition.*

Modern Poetry. A curious phenomenon in poetry was the rise of 'Dadaism,' the cult of the subconscious, in 1916. The Rumanian Tzara, writing in French, was, with Philippe Soupault, responsible for this new movement, which may, however, be linked with Rimbaud and his disciple, Guillaume Apollinaire.

Of more permanent interest is Paul Valéry (b. 1871), who wrote in the traditional manner, achieving perfection of form. His best work is in 'Le Cimetière Marin.' Jean Giraudoux (b. 1882), Paul Morand (b. 1888), Jean Cocteau (b. 1892) and François Mauriac (b. 1885) were Dadaist poets who turned to novel- and play-writing.

MODERN NOVELISTS. *Paul Bourget (left) applied his scientific training to his novels, which are sound psychological studies. The colourful romances of Pierre Loti (right) have a strongly individual style.*

Photo, left, E.N.A.

Modern Drama. In drama, at the end of the century, the problem play had a great vogue in the hands of such writers as Paul Hervieu and Eugène Brieux. Poetic drama had been revived by Bornier and Coppée. In this genre Edmond Rostand (1868–1918) excelled; 'Cyrano de Bergerac' became world-famous. Bernstein has had success in emotional drama, and among the social satirists are Lavedan, Lemaitre, Donnay, Bataille, Courteline, Tristan Bernard and Sacha Guitry. The famous novelists Mauriac, Rolland and Romains have essayed drama; Romains' 'Knock' won fame. Original work

RECENT FRENCH WRITERS. The dramatist Edmond Rostand (left) excelled in poetic plays, of which 'Cyrano de Bergerac' is world-famous. His son Maurice is a well-known dramatist and novelist. Marcel Proust (right), a most original stylist, produced a much-discussed series of discursive novels in which poetry and psycho-analysis are skilfully blended. His work, dealing with his own social background, has remarkable actuality.

has been done by Cocteau, Giraudoux, Obey, Maurice Rostand and others. Outstanding is Jean-Jacques Bernard (b. 1888), whose fine plays show deep psychological insight.

Later Novelists. Most original of modern writers was Marcel Proust (1871–1922). 'A la Recherche du Temps Perdu' (7 vols.) is a synthesis of his own life and social background, written in a curiously involuted style. It has been translated under the titles 'Swann's Way,' 'Within a Budding Grove,' 'The Guermantes Way,' 'Cities of the Plain,' 'The Captive,' 'The Sweet Cheat Gone' and 'Time Regained.'

André Gide (b. 1869) has had considerable influence; he is himself influenced by the Russian novelists and by Nietzsche, and has a native wit. Georges Duhamel (b. 1884) achieved fame with his psychologically subtle 'Salavin' and the series of novels about the Pasquier family. Jules Romains (b. 1885) is best known for his series translated as 'Men of Good Will.' André Maurois (b. 1885), whose real name is Emile Herzog, attracted notice with his first novel, 'Les Silences du Colonel Bramble' (1918), and produced a long list of novels and biographies, the best known being 'Ariel,' his fictional life of Shelley, and 'Byron.'

Henri Barbusse (1873–1935) was another novelist who became a celebrity with a war novel, 'Le Feu' (Under Fire); and Romain Rolland, distinguished as biographer and essayist, produced the vast 'Jean-Christophe' (10 vols.), a Nobel prizewinner. Roger Martin du Gard (b. 1881), author of the Thibault family saga, also won the Nobel Prize. Morand's cosmopolitan work is very popular, and the poignant tales of Mauriac touch greatness. Fine work has been done by Cocteau, Bloch, Carco, MacOrlan, Vercel, Lacretelle, Hamp, Bernanos, Malraux, Aragon, Giono, Varende, Jouhaudeau, Kessel and others.

LESSON SIX

Spanish I: Early Times to the Golden Age

SPAIN possesses one of the finest European literatures: in poetry and drama, novel, historical romance and the short story, her writers have produced original work of the highest importance, much of which is familiar in translation to English readers. The language in which the main body of Spanish literature has been written is known as Castilian (having been the language of Old and New Castile), which became the established national tongue when Ferdinand and Isabella of Castile had redeemed the country from the last of the Moors at Granada.

Portuguese and Catalan have many affinities with Castilian, but both long since attained to the status of independent languages, Portuguese boasting a literature of surprising richness relative to the population of the country, and Catalan also possessing a considerable literature, as becomes an idiom evolved from the general speech of Aragon and Roussillon before the rise of Castilian and serving still as the daily medium of between two and three million Spanish people in the Eastern provinces from the Pyrenees to Alicante. Though not of academic rank, Catalan (*see* page 319) must be regarded as a language. Galician (*see* page 324) is only a dialect of Portuguese.

The Cid. Spanish literature begins with the 'Cantar de mio Cid,' a noble epic by an unknown minstrel dealing with the adventures of the warrior Rodrigo Diaz de Bivar (d. 1099); 'Cid' is an Arabic title (Sid) meaning 'lord.' This poem appeared in

1140 and may owe something to the 'Chanson de Roland' (11th cent.). French influence was strong at the time, as was Arabic; after the recapture of Toledo from the Moors (1085), oriental studies were fostered there.

In the 13th century religious poetry flourished, and Gonzalvo de Berceo, a Benedictine monk, wrote his beautiful naïve legends of the saints.

Alfonso X of Castile (1252–84), a most enlightened monarch known as 'El Sabio' (the Sage), was responsible for many compilations of the utmost value, including some from oriental sources. The 'Crónica general' was the first of the numerous chronicles. To 'El Sabio' we owe the richly illuminated manuscript of the 'Cántigas de Santa Maria,' in the Galician dialect, a treasury of poetry and music.

Alfonso's son, the Infante Don Juan Manuel (1282–*c.*1349), wrote 'Conde Lucanor,' an admirable series of 50 tales skilfully linked together in the manner of the 'Arabian Nights.'

We come now to that great poet Juan Ruiz (*c.* 1285–*c.*1350), Archpriest of Hita (near Guadalajara), who wrote the delightful 'Libro de buen Amor' (Book of True Love), a series of poems linked together in the oriental fashion and amounting in all to about 7,000 lines. He himself is obviously the central figure, a large, robust man, high-coloured, vital, full of 'joie de vivre.' He was evidently ill-fitted for the priestly life, for he flits from one love affair to another and is frequently profane; probably, however, he was no more debauched than most of his fellow-ecclesiastics in a corrupt age. An uncompromising realist, his world is a gay rough-and-tumble, with no chivalry, unselfishness or purity in it. But the genius of the man is beyond controversy, and he is never dull. He has been compared with Chaucer, with whom indeed he has much in common, but the world of Juan Ruiz contains no 'parfait gentil knight' or poor parson, no patient Griselda or steadfast Constance. He was a born story-teller and a consummate master of metre, often using the 'cuaderna via,' a stanza of four lines, each of 14 syllables, with the same rhyme. This translation gives an idea of it:

I wish to make my sermon brief, to shorten my oration—
For a never-ending sermon is our utter detestation:
I like short women; suits at law without procrastination—
And am always most delighted with things of short duration.

In a little precious stone, what splendour meets the eyes!
In a little lump of sugar how much of sweetness lies!
So, in a little woman love grows and multiplies;
Remember what the old saw says—a word unto the wise.

There's naught can be compared to her, throughout the wide creation;
She is a paradise on earth—our greatest consolation,
So cheerful, gay and happy, so free from all vexation:
In fine, she's better in the proof than in anticipation.

In the 15th century, the outstanding name is that of the Marqués de Santillana (1398-1458), who, like Don Juan Manuel, led a busy life in the service of his country. A fine scholar and an ardent lover of literature, he wrote charming lyrics and introduced the Petrarchan sonnet into Spain. At the same period, Francisco Imperial is noteworthy; his 'Dezin a las syete virtudes' is an imitation of Dante.

Chivalrous romance reached Spain from France in the 14th century, 'Amadis de Gaul' being best known. In a much shortened and perfected form, this epic material became ballads to be sung to music; many of them were collected in the 'Cancionero de Romances' (*c.* 1550). Outstanding in ballad literature is 'Conde Arnaldos,' which probably dates from the 16th century.

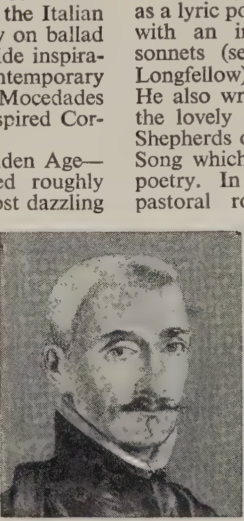
La Celestina. A most important influence was the 'Tragicomedia de Calisto y Melibea' (1499), now known as 'La Celestina,' a prose masterpiece of extraordinary power which, for its noble conception, dramatic dialogue and superb character-drawing, is now recognized as one of the classics of European literature. The author is thought to be Fernando de Rojas, who was Mayor of Talavera up to 1538. He tells a story of overpowering love turned to guilty passion by the misdirection of the villainous old woman Celestina, whose avarice at last overreaches itself. The lovers are ill-fated, and Celestina meets her own death at the hands of accomplices whom she has betrayed. This prodigy of evil is one of the most dynamic creations in literature.

'La Celestina' owes something to Juan Ruiz. A forerunner of the picaresque novel, it became extremely popular and was translated throughout Europe. The fine English version by James Mabbe appeared in 1631, but the story was already well known through an anonymous play (1520–30) which may have inspired Shakespeare when he wrote his 'Romeo and Juliet.'

Drama. The beginnings of drama in Spain were much the same as in England and France. The Portuguese Gil Vicente (*see* page 320) was the first important figure. Lope de Rueda (d. 1565) toured Spain with an Italian company presenting 'commedia dell' arte'; his own plays show the Italian influence. Juan de la Cueva drew on ballad material which was later to provide inspiration for Lope de Vega and his contemporary Guillén de Castro, author of 'Las Mocedades del Cid' (1618), the play that inspired Corneille's 'Le Cid.'

We have now reached the Golden Age—'Siglo de Oro'—which extended roughly from 1550 to 1660. One of its most dazzling luminaries is Lope Felix de Vega Carpio (1562–1635), best known as Lope de Vega. It is interesting to note that he saw active service in the galleon 'San Juan' which sailed with the Spanish Armada and fortunately made its way safely home round the coasts of Scotland.

Lope wrote his first play at the age of 12. It has been estimated, on good evidence, that he wrote altogether about 1,600 to 1,800 plays and some 400 autos (one-act plays on religious subjects). This may seem incredible, but he himself has recorded that 100 of them took no more than a day apiece to write. There actually remain to us no fewer than 470 plays and about 50 autos, which is a sufficiently astounding total; these were published in an edition of 25 volumes (1604–47). Some of them have historical subjects; others belong to the 'comedia de capa y espada,' or drama of intrigue, in which the characters wear the cape and sword.



LOPE DE VEGA. The first of Spain's great dramatists, Lope had a stupendous and varied output, excelling also in poetry. He was Shakespeare's contemporary.

Among the best known are 'El mejor Alcalde el Rey' ('The King's the Best Alcalde'—i.e. Mayor), 'El Perro del Hortelano' ('The Gardener's Dog') and 'Fuente Ovejuna' ('The Sheep Well'), which have been translated, together with a typical cloak and sword play, 'Lo Cierto por lo Dudoso' ('A Certainty for a Doubt'), by J. G. Underhill. 'Fuente Ovejuna' is a story of conflict between the common people and their absolutist rulers; it has been played here as 'The Spanish Village,' following its great success in the Soviet Union. The class struggle also appears in 'El mejor Alcalde el Rey' and in the fine 'Peribáñez.' Other outstanding plays which have been translated are 'La Imperial de Otún' ('The Crown of Otun') and 'La Dama Boba.' Lope de Vega's main contribution to drama lies in his widening of its scope and in his skilful craftsmanship.

Not only was he a superb dramatist, but as a lyric poet, too, Lope is in the front rank, with an immense output, including 700 sonnets (several have been translated by Longfellow), and some exquisite ballads. He also wrote epics, epistles and pastorals; the lovely 'Los Pastores de Belén' ('The Shepherds of Bethlehem') contains a Cradle Song which is among the gems of Spanish poetry. In prose, he was the author of a pastoral romance, 'Arcadia,' and other novels. Lope de Vega's non-dramatic works have been collected in 21 volumes. Of verse alone, he wrote several million lines! Well might Cervantes call him a 'monster of Nature.'

On the stage, Lope had many followers. Juan Ruiz de Alarcón excelled in the comedy of character; his 'La Verdad Sospechosa' was the model for Corneille's 'Le Menteur.' But the outstanding figure, in succession to Lope de Vega, was Pedro Calderón de la Barca (1600–81), who wrote about 80 autos and a large number of comedies; 'El Alcalde de Zalamea,' 'La Vida es sueño' and 'El Médico de su Honra' are especially notable. Calderón's works have been widely translated and attracted the notice of such critics as Tieck, Schlegel, Goethe, Tennyson, Edward Fitzgerald and R. C. Trench; hence his reputation abroad has been greater than that of Lope de Vega, but to Spanish critics, and to all who know the language well enough to be able to read the works of both dramatists, it is Lope who is pre-eminent.

Poetry of the Golden Age. In poetry, the Golden Age was heralded by Garcilasso de la Vega (1503–36), a knightly figure who has been compared with our own Sir Philip Sidney. He wrote little, but the rare beauty of his verse sets him among the classics; Cervantes and Lope de Vega regarded him as supreme above all other Spanish poets. He did much to ensure the triumph of the Italian school, in which Petrarchan idealism and verse-forms were predominant.

Luis de Góngora y Argote (1561–1627) is so important that he has given his name to the period. Góngora was a great poet in the baroque manner, and much of his work has a rare beauty. It can be said of him paradoxically that graceful artificialities were his natural mode of expression, but, carried to an extreme by imitators who lacked his genius, what was original and effective in him became mere mannerism in them, and 'Gongorism,' with its inversions, its far-fetched vocabulary and its conceits, proved to be a harmful influence.

Góngora's less mannered work has returned to favour in recent years, and Mr. J. W. Barker, Cambridge lecturer in Spanish, edited in 1942 a valuable selection of his poetry with a scholarly introduction which should be read by the serious student of Spanish literature. As an example of his consummate art in shaping the form and setting the tune for his thought, we quote this lovely stanza from one of his letrillas (brief lyrics for music):

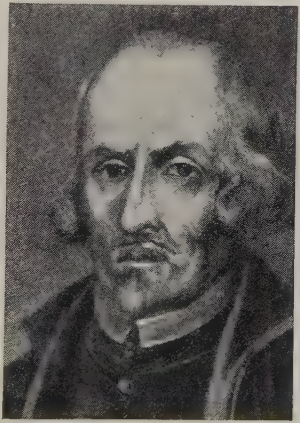
> Las flores del romero
>   niña Isabel,
> hoy son flores azules,
>   mañana seran miel.

A literal translation is: 'The flowers of the rosemary, little Isabel, today are blue flowers; tomorrow they will be honey.'

Unaffected by Gongorism were the two most memorable poets of this period. Bartholomé Leonardo de Argensola (1562–1631), a renowned Classicist, wrote pure and noble verse modelled on that of Horace. A more original genius was Francisco de Rioja (*c.* 1583–1659), whose exquisite lyrics have the freshness and rare quality of Ronsard or Herrick. Rioja was a canon of Seville and a friend of Lope de Vega. His work remained unpublished until the end of the 18th century.

The famous Portuguese poet and dramatist, Gil Vicente (*see* page 320), must also be mentioned here, for he wrote in Spanish as well as in Portuguese, and his Spanish lyrics are among the loveliest in the language.

The Mystics. This was the great age of mysticism in Spain; it produced Friar Luis de León (1528–91), who, whether in poetry or in prose, is one of the glories of Spanish literature; San Juan de la Cruz (St. John of the Cross, 1542–91), in whom is the very essence of mysticism; and the anonymous author of a magnificent sonnet, 'On Christ Crucified.' In prose, Teresa de Cepeda de Alcumuda, who became Santa Teresa (1515–82), achieved a beautiful blend of idealism and practicality.



CALDERÓN. This famous dramatist wrote over a hundred plays, mostly comedies and religious pieces. He entered the Church at the age of 50, but continued writing up to his death.

The Novel. The period was extraordinarily rich in fiction. Spain now gave the world a new type of novel, the 'picaresca,' a novel of manners whose central figure was a rogue ('picaro'). As we have seen, the 'Libro de buen Amor' and 'La Celestina' had foreshadowed this. The first picaresque novel, pure and simple, was 'Lazarillo de Tormes,' written by an unknown author in the middle of the 16th century; it had numerous imitators, notably 'Guzmán de Alfarache' (1599) by Mateo Alemán, 'La Pícara Justina' (1605) by Francisco López de Ubeda, and the memorable 'Vida del Buscón llamado Don Pablos' (1626) by the satirist Francisco Gómez de Quevedo y Villagas (1580–1645), who also attacked vice in his 'Sueños' and in other poetic works. In England the picaresque novel began with Nash's 'The Unfortunate Traveller' (1594) and found its chief exponents later in Defoe, Fielding and Smollett. In France, 'Gil Blas' is a notable example; the genre continued down to Gautier's 'Le Capitaine Fracasse.' It made its way into other literatures also.

The Italianate pastoral romance, derived from Sannazaro's 'Arcadia' (*see* page 328), is exemplified in the 'Diana' of the Portuguese Montemayor, the 'Galatea' of Cervantes and the 'Arcadia' of Lope de Vega.

A third type, the novel of adventure, was also Italian in origin. Cervantes introduced it to Spain in his 'Novelas Exemplares,' which consists of 12 'novelli' or short stories translated in 1640; two of these stories, 'Rinconete and Cortadillo' and 'The Colloquy of the Dogs,' are masterpieces. From the adventure novel developed the type which blends social commentary with adventure, as in the notable 'Marcos de Obregón' (1618) of Vicente Martínez Espinel (1551–1624), which was the main source of 'Gil Blas' (*see* page 301).

Cervantes. We come now to Miguel de Cervantes Saavedra (1547–1616), whose world-famous 'Don Quixote' appeared in two parts, in 1605 and 1615. Cervantes was a poet and a dramatist, but undistinguished in either capacity, and as we have seen, he wrote stories of various types. When he began 'Don Quixote,' his object was to destroy by ridicule the spate of romances of chivalry then being published. He found himself so gripped that he went far beyond his original conception, producing a monumental prose-epic, in which the central characters are not mere figures of fun, but thoroughly human and lovable, with ideals which we respect.

What is 'Don Quixote' and why is it so great a book? It is a long novel in two parts, a story of adventure on a panoramic scale into which over 600 characters are introduced; it deals with two fundamental and conflicting aspects of man's nature—the idealistic and the realistic. Half crazed by reading romances, Don Quixote conceives himself to be a knight and sets out to make the world a better place than it is. Sancho Panza, whom he appoints to be his squire, goes with him. They become involved in ludicrous adventures springing from the old man's illusions. He always explains his grandiose ideas to his squire, who with down-to-earth realism, often queries them.

TWO BELOVED FIGURES. These lifelike statues of Don Quixote and Sancho Panza form part of the monument to the great novelist in Spanish Place, Madrid. Cervantes' grave in the Trinitarian convent bore no memorial.

CERVANTES. This portrait of Spain's most celebrated writer was first brought to notice in 1911, and was approved as authentic by the Spanish Academy. It is signed by the painter Juan de Jauregni and dated 1600.

Here is a masterpiece of sheer entertainment, of humour and pathos, of simple but penetrating thought and kindly philosophy. The adventures of Don Quixote and Sancho Panza have captivated the imagination and won the respect of philosophers from Locke to Kant, of poets from Racine to Shelley, and of great novelists and writers of all countries. The whole life of Spain is poured into this book. And, from its wisdom and foolishness, one obtains an insight into the Spanish evaluation of the dignity of man. To add a second part to such a work is always a dangerous experiment, but critics are of opinion that in literary artistry, if not in variety of adventures, the second part is even better than the first.

'Don Quixote' marked the end of medievalism and heralded the new qualities of observation and analysis which characterize modernism. It set an extraordinarily high standard of prose writing, and so robust is its quality that it seems destined to hold its place for all time. The best English translation is John Ormsby's, though those of Jarvis and Le Motteux are more popular. In our Course on Spanish (Vol. IV, pp. 500–2), we give an extract from the original, with a literal translation.

Historians. History and travel are well represented in this period. In Juan de Mariana (1535–1624), we have the greatest of the Spanish historians. This famous Jesuit was the forerunner of the 'scientific' historians of our own times. His ability to sift historical evidence, his power of co-ordination, his fearlessness in presentation, were combined with exceptional gifts as a writer. It has been said of his 'History of Spain' that it is 'the most remarkable union of picturesque chronicling with sober history that the world has ever seen.'

Among the travel-writers, Bartolomé de las Casas (1474–1566), bishop of Chiapa, is most important. A friend of Columbus, he wrote a 'History of the Indies' which gives much valuable first-hand information.

With the 17th century a great age ended, to be followed by a period of imitativeness, in which foreign influences, especially French, were predominant.

LESSON SEVEN

Spanish II: 18th Century Onwards

THE political decline of Spain was accompanied by a period of decay and sterility in literature. No name comparable with the great names of the Golden Age can be recorded during the 18th century. There were, however, three important events: the foundation of the National Library in 1711, of the Royal Academy in 1714 and of the Royal Academy of History in 1738. To these admirable institutions we are indebted for the conservation of much that is best in the language and literature. The Royal Academy published a magnificent Dictionary in six folios, and afterwards a Grammar.

Ignacio de Luzán, a disciple of Boileau, did much to formalize Spanish literature according to French neo-classic models. His 'Poética' appeared in 1737.

There was a dearth of lyric poetry. Juan Meléndez Valdés (1754–1817), leader of the classicists, was an accomplished poet, whose Odes, 'Los Besos de Amor,' have been highly praised. Memorable, too, are the fabulists Felix Maria Samaniego (1745–1801) and Tomas de Iriarte (1750–91). In drama, Ramón de la Cruz y Cano (1731–94) translated 'Hamlet' and wrote many amusing plays in which we can find a vivid record of contemporary society. Leandro Fernández de Moratín (1760–1828) wrote two outstanding plays, 'El Sí de las Niñas' and 'La Comedia Nueva,' besides admirable essays and verse.

One novel of merit continued the picaresque tradition—'The History of the Famous Preacher Fray Gerundio de Campazos, alias Zotes,' by the Jesuit Josef Francisco de Isla (1703–81). Its central figure, though almost illiterate, has the knack of bad oratory.

Romantic Poets. The Romantic Revival appears first in the work of the Duke of Rivas, poet and dramatist, and then in the passionate and Byronic figure of José de Espronceda (1808–42), whose tragic love-story is commemorated in 'El Diabolo Mundo.' The magnificent 'El Pirata' is reminiscent of 'The Corsair,' and 'El Estudiante de Salamanca' is modelled on 'Don Juan.' Espronceda has been compared with Swinburne for his mastery of rhythm; this may be seen in the slow harmonies of his glorious 'Hymn to the Sun.'

The Byronic influence is also noteworthy in José Zorrilla (1817–93), author of 'Don Juan Tenorio,' a play which has taken its place in the national repertory. Zorrilla was also a fine descriptive poet. His work is strongly national.

Later 19th Century Poets. In the later half of the century, the most notable poets are Ramón de Campoamor (1817–1901) and Gaspar Núñez de Arce (1834–1903). Campoamor, a gay man of the world, wrote many delightful lyrics, of which 'Quién Supiera Escribir,' 'El Gaitero de Gijón,' 'Lo que hace el tiempo' and 'El Beso' are typical. Núñez de Arce, a Castilian gentleman, was the greatest poet of his time. His best work is in the 'Gritos del Combate,' 'Última Lamentación de Lord Byron,' 'El Idilio,' 'La selva obscura,' 'El vertigo' and 'La visión de Fray Martin.'

Other poets of note are Joaquín María Bartrina (1850–80), a follower of Leconte de Lisle; Vicente Wenceslao Querol (1836–89), author of the lovely 'Cartas á Maria' and 'La Fiesta de Venus'; the Andalusian Salvador Rueda Santos (b. 1857); the Murcian Vicente Medina (b.1866); José María Gabriel y Galán (1870–1905), whose 'El Ama' and 'El Cristu benditu' are outstanding; and the Galician Rosalía de Castro (*see* page 324), who wrote one volume in Spanish.

Drama. In drama, Ventura de la Vega (1807–65), a disciple of Moratín, wrote 'El Hombre de Mundo' in the tradition of Molière. Tamayo y Bans was popular, but he was eclipsed by José Echegaray (1832–1916), an extremely versatile writer who began his career as professor of mathematics, became minister of education and minister of finance, and was a most successful business man. In literature, he made his mark as a philosopher and a poet, but he is best known as a dramatist. He wrote over 80 plays and had a tremendous influence. His early plays are Romantic, but he went on to social drama and also to symbolism. Best known of his plays are: 'La Esposa del Vengador,' 'El Gran Galeoto,' 'Mariana,' 'El Hijo de Don Juan' and 'El Loco Dios.'

Jacinto Benavente (1866–1939), a most prolific and versatile dramatist, dominated the stage for many years. 'La Comida de las Fieras,' 'La Noche del Sábado,' 'Rozas de Otoño,' 'Les Intereses Creados,' 'La Malquerida,' 'La Mariposa' and 'Almas Fuertes' were his most successful plays, ranging from light comedy to powerful tragedy. Several of his plays have been translated by J. G. Underhill; the best known, to English and American readers, is the lively one-act comedy, 'No Smoking.'

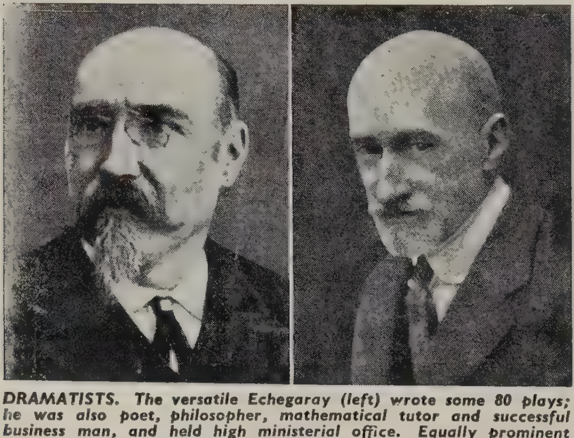
Fiction. A reaction against Romanticism began with Fernán Caballero (1796–1877); she wrote realistic novels in an unassuming style. Pedro Antonio de Alarcón (1833–91) will be remembered for 'El Sombrero de Tres Picos' ('The Three-Cornered Hat'), a charming Andalusian tale, inspired by traditional ballads and song. José María de Pereda (1833-1906) was the founder of the realistic school. His best loved novel is 'Sotileza.'

Most important was Juan Valera (1824–1905), professor and politician. He had a tremendous and lasting success with the idyllic 'Pepita Jiménez' (1874), which may be read in translated form. It is an essentially Spanish story, written with much subtlety and humour. Other excellent novels were 'El Comendador Mendoza,' 'Doña Luz,' 'Juanita la Larga' and 'Genio y Figura.' Valera earned enthusiastic praise from Coventry Patmore and other critics, and he was himself a noted critic, who did much to mould good taste.

Another brilliant novelist was Benito Pérez Galdós (1843–1920), who wrote the splendid series of historical novels entitled 'Episodios Nacionales' (46 vols., 1873–1912), of which 'Trafalgar' is one of the most interesting. Of his other novels, the most notable are 'Doña Perfecta,' 'Gloria,' 'La Familia de León Roch,' the beautiful 'Marianela,' the Zolaesque 'Lo Prohibido' and 'Realidad,' the profound social commentaries 'Fortunata y Jacinta' and 'Angel Guerra,' and later, 'La Loca de la Casa,' the 'Torquemada' trilogy, 'Misericordia,' 'El Abuelo' and 'Casandra.'

This was indeed a great period for fiction. Emilia, Countess of Pardo-Bazán (1851–1921), wrote powerful, even brutal, studies of peasant life in 'Los Pazos de Ulloa,' 'La Madre Naturaleza,' and 'De mi tierra.' She was influenced by Zola. Armando Palacio Valdés (b. 1853) won fame with 'El Señorito Octavio,' 'Marta y María,' 'Jose,' 'Riverita,' 'La Hermana San Sulpicio,' and other stories.

Angel Ganivet (1865–98) will long be remembered for 'Los Trabajos del infatigable creador Pio Cio' and Ramón del Valle Inclán (b. 1869) for his 'Sonatas,' a series of four novels of unusual interest. Under the dictatorship of Primo Rivera, he became a Republican; his 'Tirano Banderas' is an incitement to revolt. Later, Valle Inclán produced a cycle which has been translated as 'Iberian Roundabout'; this castigates the monarchy and the court.



DRAMATISTS. The versatile Echegaray (left) wrote some 80 plays; he was also poet, philosopher, mathematical tutor and successful business man, and held high ministerial office. Equally prominent and very prolific, Benavente (right) had a very wide range in drama.

Photos, E.N.A.

BRILLIANT NOVELISTS. *Pérez-Galdós (left) was the author of very many excellent novels, including the monumental 'Episodios Nacionales,' a group of 46. The vivid work of Blasco Ibáñez (right) has won extended fame in translation.*

Photo, left, E.N.A.

Of world-wide reputation was Vicente Blasco Ibáñez (1867–1928), a realist who depicts glowing romantic scenes and passions in a naturalistic manner. To English readers he is best known by such flamboyant successes as 'Blood and Sand,' 'The Four Horsemen of the Apocalypse,' 'The Shadow of the Cathedral,' 'Enemies of Women' and 'Mare Nostrum.' His finest work, however, is in the early novels and short stories dealing with his native Valencia; of these, 'La Barraca' ('The Cabin') and 'Entre Naranjos' (translated as 'The Torrent') are outstanding. Because of his Republican activities, the novels of Ibáñez have been banned in Spain.

Pío Baroja (b. 1872), a Basque, began his career with a volume of short stories, 'Vidas sombrías,' afterwards retitled 'Idilios Vascos'; this was an immediate success, and was translated as 'Shadowed Lives.' He has written a great many other novels, notably the trilogy known to us as 'Struggle for Life,' 'The Quest' and 'Red Dawn,' which deals with the Madrid underworld, under the influence of Gorki. Spain's most distinguished woman writer, Concha Espina, has produced many brilliantly penetrating psychological novels; her best known is 'La Esfinge Maragata.'

Ramón Pérez de Ayala (b. 1880), a talented poet, critic and essayist, is the author of several powerful novels. His first book, 'A.M.D.G.,' is an attack on the Jesuit college where he was educated. 'Belarmino y Apolonio' and 'Tigre Juan' are his masterpieces. Essentially Spanish, they are written in a highly individual style, with an enormous vocabulary; this makes them difficult, if not impossible, to translate. Another novelist of distinction is Gabriel Miró (1879–1930), who wrote of his native Alicante in slow reposeful prose. 'El Humo Dormido' and 'Figuras de la Pasión del Señor' are his best work. Notable, too, is Salvador de Madariaga (b. 1886), who was Professor of Spanish Studies at Oxford (1928–31) and then Spanish Ambassador to the U.S.A. Under the pseudonym 'Julio Arceval,' he wrote the delightfully satirical 'Arceval y los Ingleses' and 'La Jirafa Sagrada'; the latter was first published in English as 'The Sacred Giraffe.' Of the more recent novelists, Felix Urabayen and Claudio de la Torre should be noted.

THINKERS. *The critic 'Azorín' (left) has distinguished himself in belles lettres, as also in his novels. Unamuno (right) was Spain's foremost thinker of recent times; his work, imbued with mysticism, has a rare beauty. A man of vigorous thought, he opposed the Franco régime.*

Contemporary Thought. Within our own times the dominant figure has been Miguel de Unamuno (1864–1937), Professor of Greek Literature and subsequently Rector at Salamanca University. A mystic, he combined the most spiritual elements of Eastern and Western thought in an attempt to harmonize man with the universe. His masterpiece is 'Del Sentimento Trágico de la Vida,' of which there is an excellent translation, 'The Tragic Sense of Life.' The 'Vida de Don Quijote y Sancho' is also famous. Unamuno wrote essays, treatises, novels, verse and a play ('Fedra'). His anti-monarchist views led to his exile in 1924; this was soon annulled. In 1936 he returned to Salamanca University to make a public protest against the Franco régime, and shortly afterwards died there from a clot on the brain.

A remarkable thinker, too, is José Ortega y Gasset, critic and psychologist, who has produced illuminating commentaries on current events and on the implications of Einstein's discoveries. José Martínez Ruiz (b. 1876), writing as 'Azorín,' excels in imaginative essays and in literary criticism.

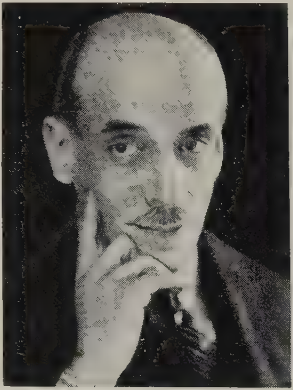
Modern Dramatists. Drama has flourished recently, the work of Benavente being supplemented by that of other excellent dramatists.

THE BROTHERS QUINTERO. Widely loved are the plays of Serafín (left) and Joaquín (right) Alvarez Quintero, written in collaboration. Witty comedies, they are made memorable by their depth of feeling and piquancy of situation.

Photo, E.N.A.

The brothers Alvarez Quintero (Serafín, 1871–1938; Joaquín, 1873–1944), who worked in collaboration, produced a long list of comedies, in which 'the tears of things' are often blended with the humour. We have excellent translations by Helen and Harley Granville-Barker of 'Puebla de las Mujeres' ('The Women's Town'), 'El Centenario' ('A Hundred Years Old'), 'Fortunato' and 'La Consulesa' ('The Lady from Alfaqueque'); these, as also 'La Flor de la Vida' ('The Fountain of Youth') are occasionally performed. 'Las de Cain' is also especially notable.

Another dramatist who is appreciated in England, Gregorio Martínez Sierra (b. 1881) usually writes in collaboration with his wife; several of their plays have been translated, the most famous being 'Canción de Cuña' ('Cradle Song'), 'Navidad' ('Holy Night'), 'El Reino de Dios' ('The Kingdom of God') and 'Sueño de una noche de Agosto' (in English as 'The Romantic Young Lady').



SIERRA. This dramatist, collaborating with his wife, has written many beautiful plays which, like the Quintero plays, have become world-famous.

Photo, E.N.A.

More recently, Jacinto Grau has come to the fore. 'El Conde Alarcos' and 'El Hijo Pródigo' made a considerable impression.

Poetry. Of the modern poets, Rubén Darío (1867–1916), a Nicaraguan, has been named 'the apostle of beauty.' Much of his work was written under the influence of the French Symbolists, and its enchantment lies in its evocative power. Darío was a consummate artist, with a rare command of rhythm. His chief work is contained in three volumes, 'Prosas profanas,' 'Cantos de Vida y Esperanza' and 'El Canto errante.'

The early work of Francisco Villaespesa (b. 1877) was influenced by Darío, but this poet has developed individually and is one of the greatest of Spanish lyric poets. His 'In Memoriam' for the death of his wife is exquisite.

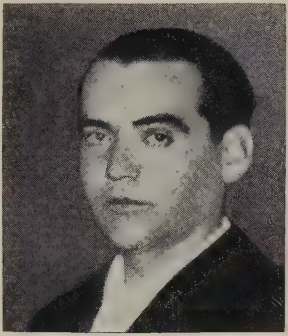
The Machado brothers (Manuel, b. 1874; Antonio, 1875–1939) are scholarly poets and dramatists. Manuel has written accomplished verse of a French elegance; Antonio, renouncing the traditional graces of style, achieved strength and beauty in his 'Soledades,' 'Campos de Castilla' and 'Poesías.'

Mentioned earlier for their work in other fields are Unamuno, whose 'Rosario de Sonetos Liricos' and 'El Cristo de Velázquez' are truly Spanish in inspiration and style; Ramón del Valle Inclán, whose 'Marquesa Rosalinda' is outstanding for its mastery of the intricacies of rhythm; Ramón Pérez de Ayala, whose 'La Paz del Sendero,' 'El Sendero Innumerable' and 'El Sendero Andante' are beautifully harmonious, and to some extent influenced by Walt Whitman; and Salvador de Madariaga, who produced in 'Romances de Ciego' a fine poetic work.

Madariaga revived interest in Spanish folk-song, of which he made a keen study.

Lorca. In recent times, the most striking poet is García Lorca (1897–1936), whose Republican sympathies caused his assassination. He was a poet who would surely have inspired modern Spanish literature to new issues, as he was in no sense derivative, though some slight influence from Walt Whitman, both in thought and form, might be traced. Perhaps his most characteristic work is in 'Yerma' (1934), a strangely moving drama of a barren woman, and in his great lament for a bullfighter, 'Llanto por Ignacio Sánchez Mejías' (1935), which is one of the most original poems of this century. Even in some of his exquisite short lyrics there is an extraordinary depth of feeling. We give a typical example, selected from the fine edition of his poems translated by Stephen Spender and J. L. Gili (The Dolphin Book Co., 1942):

PUEBLO	VILLAGE
Sobre el monte pelado	On the bare mountain
un calvario.	a calvary.
Agua clara	Clear water
y olivos centenarios.	and centennial olive trees.
Por las callejas	Through the streets
hombres embozados,	cloaked men,
y en las torres	and in the towers
veletas girando.	vanes rotating.
Eternamente	Eternally
girando.	rotating.
Oh, pueblo perdido,	O lost village
en la Andalucía del llanto!	in Andalusia of the lament!



LORCA. The deeply moving poetry of this original genius was cut short prematurely, but Lorca is among the world's great lyricists.

Photo, E.N.A.

Though the English translation here is quite successful, it is little more than a transliteration, as any Spanish student will observe, and it cannot be pretended that the poetic value of the Spanish words is readily capable of being conveyed into English.

The Spanish War of 1936–39 ended with a great exodus of contemporary writers to Mexico and other Spanish American countries, where, for a while, they carried on the great traditions in exile.

Catalan Literature. A brief account must be given of Catalan literature, which in its early days was closely related with that of Provence. Catalan poets, until late in the 13th century, used the 'langue d'oc' and the poetic forms of the Provençal troubadours. This may be seen in the mystic verse of Raymond Lully (1235–1315), known also as Ramón Lull, who in addition wrote informative and didactic works in prose.

Gradually the Catalan language discarded Provençal elements, and in the 15th century there was a great outburst of native Catalan poetry, to which the chief contributors were Auzías March (1379–1459), whose 'Cants d'amor' and 'Cants de mort' mark the apex of Catalan achievement, Joan Roiç de Corella (1430–1500), author of the 'Tragedia de Caldesa,' and Jaume Roig (d. 1478), who wrote the 'Spill des dones,' a satire on women.

Soon, however, the ascendancy of Castile was marked by the fact that a Catalan poet, Juan Boscán, was one of those who founded a new Italianate school of poetry in the Castilian tongue. Catalan lapsed almost to the level of a dialect, producing in the 16th century a graceful poet, Pere Serafi, but, except for a few antiquarians, uninteresting until the language revival which occurred during the 19th century.

We then have, among many other poets, the mystic Jacinte Verdaguer (1845–1902), author of a noble epic, 'L'Atlántida,' on Columbus; Tomá Aguiló and Miguel Costai Llabera, writing of their native Majorca; and Joan Maragall, a truly great poet.

In prose, Narciso Oller's novel 'Papallona' should be noted. The outstanding writer was Eugeni d'Ors ('Xenius'), author of the lovely story, 'La Ben Plantada.'

Of the dramatists, Angel Guimerá became famous with 'Terra baixa' (1896); he wrote a great many plays with a wide range of interest. Ignacio Iglesias was at first influenced by Hauptmann, and afterwards by Maeterlinck; eventually he turned to comedy. His finest play is the social drama 'Els Vells.'

The study of the Catalan language has been fostered by the Institut D'Estudis Catalans, though this was interrupted by the Franco ban in 1939. The capital of Catalonia, Barcelona (focal centre of Republicanism), was the chief industrial city of Spain up to the time of the Civil War and will inevitably regain its commercial ascendancy. Its leading journals are printed in Spanish and many of the principal Spanish publishing houses have their headquarters in Barcelona, but there was also an extensive journalism and regional literature in the Catalan tongue.

LESSON EIGHT

Portuguese I: The First Six Centuries

Portuguese is a literary language in the fullest sense and, since the end of the 11th century, it has served as the literary vehicle of a people who are as different from the Spaniards as are the French. Their language is further removed from Latin than Castilian (Spanish); and it has many notable analogies with French.

'Cossantes' and 'Cancioneiros.' As in other countries, the development of poetry preceded that of prose. In Portugal, the earliest poetry is the lyric, not, as in France, the epic. Throughout the centuries and down to this very day, the lyric is the favourite form of the Portuguese poet. The melodious language is ideal for it. First we find the indigenous 'cossantes,' dating from the 12th century; then the poetry of the Provençal troubadours came to Portugal through Spain and, during the 13th century, the Portuguese poets adapted Provençal forms. Their work was rediscovered during the late 19th century and subsequently; until then, it had been hidden away in libraries.

The three great collections that are the fountain-heads for knowledge of this exquisite poetry are: the 'Cancioneiro da Vaticana,' 'Cancioneiro Colocci-Brancuti' and 'Cancioneiro da Ajuda.' The word 'Cancioneiro' means 'song book.' It is now recognized that the student of European literature or the lover of poetry can no more afford to neglect these collections of 'Cossantes' and Provençal lyrics than any other of the splendid cultural heritages of mankind. Many later collections have been published, and the work of research is far from finished. Few examples have been translated into English.

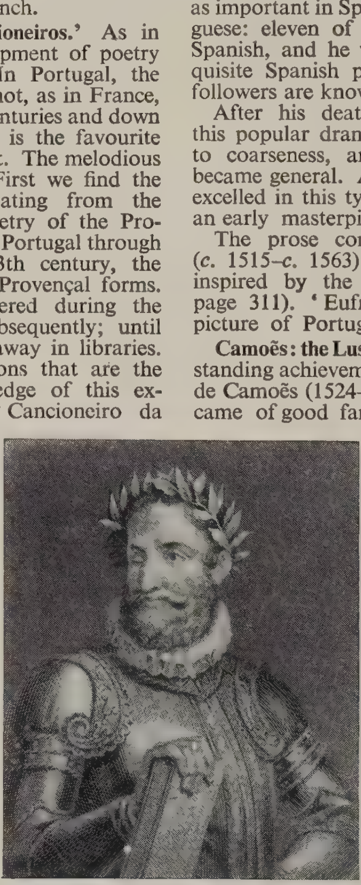
Early Drama. The first dramatist of any note in Portugal was Gil Vicente (*c.* 1465–*c.* 1536), a man of the people, whose broad humanity and lyric gifts won wide popularity. Altogether 43 of his plays survive; many of them are 'autos,' comparable with the mystery plays and moralities of our own literature, and farces. The 'Auto da Barca do Inferno' ('The Ship of Hell') is the story of a ship bound for the next world, whose passengers do not know that they are dead. Vicente was as important in Spanish literature as in Portuguese: eleven of his plays were written in Spanish, and he wrote lyrics which are exquisite Spanish poetry. He and his many followers are known as the Eschola Velha.

After his death, the Jesuits proscribed this popular drama because of its tendency to coarseness, and strictly classical plays became general. Antonio Ferreira (1528–69) excelled in this type; his 'Inés de Castro' is an early masterpiece.

The prose comedies of Jorge Ferreira (*c.* 1515–*c.* 1563) were a new development, inspired by the Spanish 'Celestina' (*see* page 311). 'Eufrosina' gives a delightful picture of Portuguese life.

Camoẽs: the Lusiads. Of epic poetry the outstanding achievement is the 'Lusiads' of Luis de Camoẽs (1524–80). Camoẽs (or Camoens) came of good family and had an excellent education, including a period at Coimbra University. He became popular in Lisbon society, and was soon known to be an accomplished poet, but because he sought to win the love of one of the Queen's ladies-in-waiting, and because of indiscretions in an early play, 'El Rei Seleuco,' he was banished from the court of João III.

Camoẽs fought against the Moors in North Africa and lost an eye. In 1552 he was back in Lisbon, but again he was in trouble owing to a quarrel with a court official. He was pardoned only on condition that he took service in India, at the Portuguese settlement of Goa, an experience which brought him great disillusionment.



***CAMOẼS.** The greatest figure in Portuguese literature, Camoẽs achieved immortality with his mighty epic, the 'Lusiads,' which glorifies his country and its empire overseas. Camoẽs had a troubled life, enduring hardship and imprisonment, and he died a poor man, before his glory had been recognized.*

For sixteen years Camoēs was engaged in expeditions and military campaigns, undergoing privations and imprisonment for debt. During this time he wrote sonnets and verses and worked on the 'Lusiads.' In his own words: 'One hand the pen and one the sword employed.' When at last he returned to Lisbon, unknown and impoverished, in 1570, it took him two years to get his great epic published.

'Os Lusiadas' ('The Feats of the Lusitanians') derives its name from Lusitania, the Latin name for Portugal. The theme is Vasco da Gama's famous voyage from Portugal round the Cape of Good Hope to discover India (1497–99). Camoēs weaves into his stirring narrative the whole proud history of the Portuguese people.

This masterpiece is divided into ten cantos containing in all 1,102 stanzas of eight lines, rhymes occurring in the first, third and fifth, the second, fourth and sixth, and the seventh and eighth. In the Course on Portuguese, Vol. IV, pp. 514–15, the student will find an example of this fine verse form, borrowed from the Italian *ottava rima.* The style is of a natural and noble simplicity, the diction is correct and elegant, and all the verse is grave, sonorous and full of sweet harmony.

'Os Lusiadas' has been translated into nearly every European language, and exists, wholly or in part, in no fewer than half a dozen English versions. In spite of many faults, that by Mickle still holds the field; Aubertin's is more accurate and almost as readable, and Sir Richard Burton's has many admirers. Camoēs wrote much else: magnificent sonnets, elegies, songs, odes and roundels, besides plays.

Poetry reached its finest flowering, as we have just seen, in Camoēs, who, in point of time, came a generation later than the three following poets. Bucolic poetry began with Bernardim Ribeiro (1482–1552), who writes naturally and with passion. Cristovam Falcão (*c.* 1512–*c.* 1553) excelled in the same genre, as did Francisco Rodriguez Lobo (*c.* 1580–1622), author of 'A Primavera' which mingles prose and poetry.

Early Prose. The earliest literary prose dates from the 14th century and consists mainly of chronicles, lives of the saints, and renderings of the Arthurian legend. Of the chroniclers, Fernão Lopez (*c.* 1380–*c.* 1460) has been called the father of Portuguese history; he is immensely vital, with Froissart's sense of the dramatic and the picturesque, but with a more philosophical background.

The Renaissance came to Portugal in part through Spain and in part directly from Italy. An important influence was the poet and dramatist Sá de Miranda (1485–1558); he had the advantage of several years' residence in Italy. From him sprang an 'Italian school' ('Os Quinhentistas'), in which we find the beginnings of modern Portuguese prose literature.

In Portugal the Classical epoch falls into three divisions: (1) the Italian School of the 16th century, (2) the Gongorist School of the 17th, (3) the French School of the 18th, bringing us to a Romantic School of the 19th century, akin to German and French Romanticism and leading on to the somewhat mixed literature of our own days.

Romances. In prose, the 16th century (the century of Camoēs) produced the tender romance known from its opening words as 'Menina e moça' by the poet Bernardim Ribeiro. In the same vein, Jorge de Montemôr, or Montemayor (*c.* 1518–61), wrote his more famous 'Diana'; this, however, was in Spanish and was based largely on the 'Arcadia' of the Italian Sannazaro (1458–1530), which had set the fashion for pastoral romance throughout Europe. The 'Lusitania Transformada' of Fernam Alvarez do Oriente (*c.* 1540–*c.* 1595) should also be noted. Francisco de Moraes (*c.* 1500–72) wrote a lively 'Chronica de Palmeirim de Inglaterra,' much admired by Cervantes, and Fernandez Trancoso (*c.* 1515–*c.* 1590) made an exceedingly popular collection of 'contes,' based mainly on Italian stories.

Travel Literature. In the 16th and 17th centuries travel literature is abundant. One could make a formidable list of at least a hundred names of intrepid travel-authors, beginning with Alvaro Velho, who kept the log of Vasco da Gama's voyage in 1492, and ending with Manoel Godinho (*c.* 1630–1712). Some of them were explorers; some were Jesuit missionaries. The most remarkable is Fernão Mendes Pinto (*c.* 1510–83). During twenty years this courageous and observant man travelled in Ethiopia, Arabia, India, China, Japan, Tartary and the East Indies. On thirteen occasions he was taken prisoner by natives. He suffered the greatest hardships, in all of which he never abandoned his notebook. The result he gave to the world in his famous 'Peregrinations,' which, written in a style of extreme simplicity and force, is in Portugal one of the most popular of all travel books. It has been translated into English, German, French and Spanish.

João de Lucena (1550–1600) wrote a history of the life and travels of Fr. Francisco

Xavier, the famous missionary, containing 'many curious things concerning Asia'; it is one of the classics of the language. We must also mention the celebrated 'Historia Tragico-Maritima,' twelve contemporary accounts of shipwrecks, afterwards collected by Bernardo Gomes de Brito (1735–36).

History and Religion. The expansion of the Portuguese Empire inspired the writing of numerous histories. João de Barros (*c.* 1496–*c.* 1570) has been called Portugal's Livy. His best known work is 'Asia'; he wrote three out of a projected four parts, which were extended to 12 parts by Diogo do Couto (1542–1616), who was the better writer of the two. Fernam de Castanheda and Gaspar Corrêa, contemporaries of Barros, also gave vivid accounts of India. In the 17th century, we have Pedro Paez's 'History of Ethiopia'; he had spent 10 years in the country and gives the first description of the sources of the Nile. Manoel Barradas and Manoel de Almeida also wrote of Ethiopia; all three were Jesuit priests. Another Jesuit, Balthazar Tellez, wrote a history of the order ('Cronica da Companhia de Jesus').

Religious writings flourished during the 16th and 17th centuries. The beautiful 'Trabalhos de Jesus' of Frei Thomé de Jesus (1529–82) have been compared with the 'Imitation of Christ'; they are intensely mystical.

The most notable author of the 17th century was D. Francisco Manoel de Mello (1608–66), but he wrote mainly in Spanish. His range was very wide, including histories, literary criticism, portraits, maxims, verse and a witty play, the 'Auto do Fidalgo Aprendiz.' Another classic writer, the Jesuit Antonio Vieira (1608–97), was famous for his 'Sermões' and for the strange 'Historia do Futuro.'

The well-known 'Cartas de uma Religiosa Portugueza' first appeared in French in 1669; it was not until 1819 that the Portuguese version was published. They were written by the nun Marianna Alcoforado to a French lover who deserted her.

Gongorism. The 17th century is known as the Gongorist period because it was influenced by the Spanish poet Luis de Góngora. Gongorism came to mean an affected elegance, a striving after the unusual. Góngora himself was a man of genius, in whom the unusual was, generally speaking, felicitous, but his followers merely produced *Cultismo*, a style consisting of inversions, complexities, forced meanings, hyperbole and over-profusion of vocabulary.

18th Century Literature. In the 18th century the most important literary events are the foundation of the Royal Academy of History (1720); the Royal Academy of the Sciences (1780); the 'Arcadia Lusitana,' or 'Arcadia Ulyssiponense' (1756), a society modelled on the Italian Arcadia, for the encouragement of good taste in poetry; and the 'Nova Arcadia' (1790). The literature of the period is alternatively known as the French or Arcadian school.

In poetry, we should note Pedro Antonio Corrêa Garção (1724–72), chief of the Arcadians, whose 'Cantata de Dido' is his outstanding work; Domingos dos Reis Quita (1728–70), a charming bucolic poet; Antonio Dinis da Cruz e Silva (1731–1799), whose racy satire 'O Hyssope,' derives from Boileau's 'Lutrin'; Manoel Maria de Barbosa du Bocage (1765–1805), José Agostinho de Macedo (1761–1831) and Francisco Manoel do Nascimento (1734–1819) whose reputations have declined; Nicolao Tolentino de Almeida (1741–1811), a gifted satirist, and Belchior Manoel Curvo Semedo (1766–1838), leaders of the 'Nova Arcadia.'

LESSON NINE

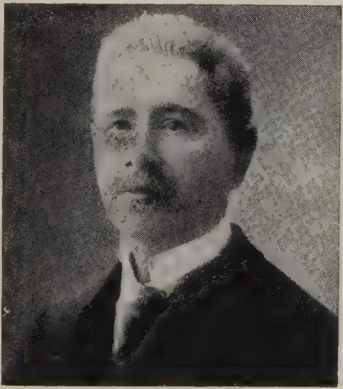
Portuguese II: 19th Century Romanticism

ROMANTICISM dominated the 19th century in Portugal, and one of its greatest exponents was Viscount Almeida Garrett (1799–1854), a strange lovable figure who made his mark in politics. He set out to give Portugal a national drama, to which he contributed several fine plays on Portuguese themes, notably the 'Auto de Gil Vicente,' 'Alfageme de Santarem' and the outstanding 'Frei Luis de Sousa.' The best of his lyric verse, collected in 'Flores sem Fructo' and 'Folhas Cahidos,' is exquisite, and his longer poems include 'Camões' and 'Dona Branca,' which did much to establish Romanticism. In prose, too, Garrett excelled; the historical novel 'O Arco de Santa Anna' was written under the influence of Sir Walter Scott, and 'Viagens na minha terra,' the account of a journey to Santarem, is a masterpiece.

The great historian Alexandre Herculano (1810–77) wrote verse which has grandeur and intense sincerity, as well as novels inspired by Scott but remarkable for an eloquence all his own. He had numerous imitators. Another historian, Joaquim Pedro de Oliveira Martins (1845–94), though less reliable, has a vigorous and colourful impressionistic style. Antero de Figueiredo (b. 1867) was his distinguished follower.

Impressionism imbues the work of Camillo Castello Branco (1825–90), who wrote many novels and short stories of contemporary life, sometimes lacking depth or probability but lit with genius and nearly always perfect in style.

Romantic Poetry. Of the Romantic poets, Antonio Feliciano de Castilho (1800–75) wrote in a flowing natural style. José da Silva Mendes Leal (1818–86), noted for his patriotic verse, was also successful as a dramatist and a novelist, as was the sentimental poet, Francisco Gomes de Amorim (1817–92), biographer of Garrett. João de Lemos (1819-89) wrote musical and scholarly verse, which was collected in his 'Cancioneiro,' and Antonio Augusto Soares de Passos (1826–60), author of the melancholy 'Poesias' and other volumes, stimulated the Romantic Movement also by his translation of Ossian. Thomaz Ribeiro (1831–1901) in a crowded life found time to produce patriotic verse; 'Don Jayme' (1862) is his finest achievement. Raimondo Antonio de Bulhão Pato (1829–1912), a voluminous writer of pleasant verse, spent about 40 years in writing his 'Paquita,' which is in the manner of Byron's 'Don Juan.'



BRAGA. A distinguished statesman, scholar and poet, Dr. Theophilo Braga was a Lisbon professor who became first President of the Republic.

Photo, E.N.A.

Reaction from Romanticism. There was, of course, a reaction from Romanticism. This is seen particularly in the novels of the second half of the century. Joaquim Guilherme Gomes Coelho (1839–71), writing as Julio Diniz, became famous at the age of 21 with 'Uma Familia Ingleza,' a Dickensian novel. 'As Pupillas do Senhor Reitor,' and other stories, are chronicles of village life, suggestive of Jane Austen.

Portugal's greatest novelist was José Maria de Eça de Queiroz (1843–1900), founder of the realistic school, a most original writer with a powerful imagination and much charm of manner. He travelled widely and his work shows a remarkable range. Best known are 'O Crime do Padre Amaro,' 'O Primo Bazilio,' 'Os Maias,' 'A Reliquia,' 'A Correspondencia de Fradique Mendes,' 'A illustre Casa de Ramires' and 'A Cidade e as Serras,' besides his masterly short stories. Eça de Queiroz was influenced by the French realists, but there is in him a vein of mysticism. His most important disciple is Aquilino Ribeiro, author of 'A Via Sinuosa' (1918), 'Filhas de Babilonia' (1925) and 'Estrada de Santiago' (1925).

Other novelists who should be noted are: Manoel da Silva Gayo (b. 1860), author of a masterly 'conto,' 'Peccado Antigo' (1893), and of 'Ultimos Crentes' (1904); Teixeira de Quieroz (1848–1919), a prolific writer of naturalistic novels and 'contos'; Jaime de Magalhães Lima (b. 1857), who wrote novels with a purpose and also 'contos'; Manoel Teixeira Gomes, an artist in prose, with the gift of vivid characterization; Raul Brandão, who wrote the magnificent 'Pescadores' and 'Os Pobres'; Manoel Ribeiro, best known for his great trilogy, 'A Catedral,' 'O Deserto' and 'A Resurreição'; and the brilliant political satirist, Campos Monteiro, whose 'Saude e Fraternidade' will be remembered.

There has been a rich crop of short stories. José Francisco de Trindade Coelho (1861–1908) was the best of the 'contistas.' His work, collected in 'Os Meus Amores' (1891), blends realism and idealism in delightful fashion and shows a sympathetic insight into peasant life.

Of the historians and literary critics, Dr. Joaquim Theophilo Braga (1843–1924), a most industrious writer and editor, rendered immense services to Portuguese literature. This distinguished statesman became the first President of the Portuguese Republic, holding office from 1910 to 1912 and again in 1915. Professor Fortunato de Almeida has produced an admirable 'Historia de Portugal' and 'Historia da Igreja em Portugal.'

Drama has continued to lack vitality. Its most notable exponents have been D. João da Camara (1852–1908), whose plays cover a wide range—historical, social, melodramatic or fanciful in type; Marcellino Mesquita (1856–1919), author of moving historical tragedies and problem plays; Henrique Lopes de Mendonça (b. 1856), whose historical plays are excelled by his realistic prose plays; and Julio Dantas (b. 1876), who has re-created the past with exquisite effect in such plays as 'A Severa' and 'Soror Mariana.'

Post-Romantic Poetry. In poetry, Anthero de Quental (1842–91) led the revolt against Romanticism; his superb sonnets ensure his immortality. Quental was profoundly influenced by German literature. A one-time student of Coimbra University, he founded the Coimbra school of poets, to which Professor Braga belonged. Braga himself wrote the epic 'Visão dos tempos.' The most natural of Portuguese poets, João de Deus (1830–96) wrote lyrics of unsurpassed beauty and simplicity; his work was collected in 'Campo de Flores.' Antonio Candido Gonçalves Crespo (1846–83), in two slender volumes, 'Miniaturas' and 'Nocturnos,' left poems so faultless that he is among the true poets.

Another fine poet, Abilio Manoel Guerra Junqueiro (1850–1923) was an enthusiastic admirer of Victor Hugo, whose influence was strong in Portugal. Guerra Junqueiro's first volume of poetry was published when he was only 14. He won fame with the powerfully ironic 'A Morte de Dom João' (1874). Patriotism inspired some of his verse, but the most moving deals with peasant life. Antonio Duarte Gomes Leal (1849–1921) is at his best in the same genre, though there is brilliance in his 'Claridades do Sul' and in the well-known 'O Anti-Christo.'

One of Portugal's finest poets, Eugenio de Castro (b. 1869) is a Symbolist. José de Sousa Monteiro (1846–1909) and Antonio Feijó (1862–1917) wrote verse of rare perfection. Cesario Verde (1855–86) was a natural poet who chose themes of natural appeal. Antonio Nobre (1867–1900), an intensely individual poet with a superb command of metre, had considerable influence with his remarkable medley 'Só' (1892), which is imbued with melancholy.

The Conde de Monsarez (1852–1913) and Augusto Gil excel in poems of the open air. Another Nature poet is Joaquim Teixeira de Pascoaes (b. 1877), who founded the school 'Saudisismo,' reviving the cult of 'saudade' and the characteristically Portuguese; he is a pantheist. João de Barros, well known as a politician, has written much stimulating verse and prose. Antonio Corrêa de Oliveira (b. 1880) is a true lyric poet, racy of the soil, while Afonso Lopes Vieira (b. 1878) is inspired by the sea.

The Galician Revival. No account of Portuguese literature is complete without a reference to the Galician writers. The Galician language is regarded as a branch of Portuguese, and it was used for literary purposes during the Middle Ages, notably by Alfonso the Sage in his 'Cantigas de Santa Maria' (*see* p. 311), but there is little true Galician literature until the great revival during the last century.

Among the early poets, Alberto Camino (1821–61) produced a small volume of impeccable verse, 'Poesías Gallegos,' which was not published until 1896. Rosalía de Castro (1837–85) became famous for her 'Cantares Gallegos' and 'Follas Novas,' which reach sheer perfection, and the blind Valentín Lamas Carvajal (1849–1906) gives a vivid picture of peasant life, notably in 'Espiñas, Follas e Frores,' 'Saudades Gallegos' and 'A Musa d'as Aldeas.' The raciness of Benito Losada (1824–91) made him popular.

Eduardo Pondal (1835–1917) a unique Ossianic figure, primeval despite his culture, gave voice to poetry which has a strange aloof grandeur, tenderness, mystery and wild music. Sometimes it is no more than a sentence, but it has incantational power.

Manoel Curros Enriquez (1851–1908), Manoel Núñez Gonzalez (1865–1917), Antonio Noriega Varela (b. 1869), Xavier Prado, with many other poets express the soul of a people who delight in song. In prose we have many excellent volumes of 'contos.'

GUERRA JUNQUEIRO. *Outstanding among modern poets, Guerra Junquiero wrote ardently and sincerely, with a strong interest in contemporary affairs.*
Photo, E.N.A.

LESSON TEN

Italian I: Middle Ages and Renaissance

It was usual for English critics, historians and educationalists of the 19th century to place Italian literature next in importance after Greek and Latin. Today there are few so bold as to make such a claim, although we recognize the historical importance of its influence on the rest of Europe, the almost unequalled poetic genius of Dante, and the fact that the Italians were our predecessors in the evolution of many literary forms, and had produced a body of considerable literature long before most other European nations, ourselves included.

Literature in Italy is, generally speaking, less important and far less expressive of the national mind than it is in France, Spain, Germany, Russia, England—and some would include Portugal. While recognizing this comparative weakness of her literature, one must put on the other side of the balance Italy's massive contribution to the arts of painting, sculpture and music, in which her great men far outnumber and (generally speaking, again) outclass her most important literary figures. Richard Garnett, critic and historian, has given us some idea of the relative place of literature in Italy's national achievement in this pregnant comment: 'It is indeed remarkable that out of the nine Italians most brilliantly conspicuous in the first rank of genius and achievement—Thomas Aquinas, Dante, Columbus, Leonardo, Michael Angelo, Rafael, Titian, Galileo and Napoleon—only one should have been a man of letters.' From this we conclude that Italian authors must be weighed rather than counted; that quality rather than quantity should be our criterion in passing judgement.

The Italian language is a modification of Latin, although we must agree with Borrow in regarding Spanish as the noblest son of the Latin father. For the development of a vernacular literature in Italy, the Tuscan dialect was to prove itself the best medium.

Towards the end of the 12th century, the Provençal troubadours had revealed the potentialities of their own vernacular; many of them were established as court poets in the kingdoms of North Italy. In Sicily, about 1220, Frederick II founded a school of poets under Provençal influence, using a vernacular which resembled the Tuscan; soon court poetry was flourishing on the mainland, especially in Tuscany and the Romagna, and by the middle of the 13th century we have many poets writing in the Tuscan.

Italian Verse Forms. Among the new metrical forms evolved, the most common were the *canzone* (can-tsō-nay) and the sonnet. The canzone followed a definite rhyming pattern, exemplified in these lines from D. G. Rossetti's translation of a poem by Guido Cavalcanti, quoted by Garnett:

> But when I looked on death made visible,
> From my heart's sojourn brought before mine eyes,
> And holding in her hand my grievous sin,
> I seemed to see my countenance, that fell,
> Shake like a shadow: my heart uttered cries,
> And my soul wept the curse that lay therein.
> Then Death: 'Thus much thine urgent prayer shall win—
> I grant thee the brief interval of youth
> At natural pity's strong soliciting.'
> And I (because I knew that moment's ruth
> But left my heart to groan for a frail space)
> Fell in the dust upon my weeping face.

The sonnet also had a definite pattern; it consisted of an octave, rhyming abababa, and a sestet, which allowed a certain amount of variety in the rhyme-scheme. The *ballata*, the *ottava rima* and the *sestina* were much used, too; examples may be found in Rossetti's translations. Byron made frequent use of the *ottava rima* (*see* Vol. I, p. 81).

Of the early Tuscan poets, Guido Cavalcanti (*c.* 1250–1300) and Cino da Pistoia (1270–1336) are most important. Cavalcanti, a friend of Dante, wrote one of the best known of all canzoni, the lovely 'Donna mi prega,' which is so closely packed with thought that it has attracted many commentators. Da Pistoia wrote love poetry which for tenderness and psychological subtlety has been surpassed only by Dante's. These two poets bring us to the finely matured work of the greatest Italian poet, Dante Alighieri (1265–1321), the Florentine.

Dante, the Creator. In Dante both poetry and prose found a master. 'La Divina Commedia' gives him a place in the front rank of the world's greatest poets. His 'Vita Nuova'—the story of his love for Beatrice—is the first notable work in Italian prose. Some of his lyrics, canzoni and sonnets are masterpieces.

Enough is known of Dante's family background to establish that he came of an old and well-to-do family; that he had for a teacher Brunetto Latini, the most learned of contemporary Florentines; and that, when a young man, he took part in several military campaigns. All available evidence indicates that he was a rich, cultured man who 'moved in the best society.' There is nothing 'common' or 'vulgar' about any of his work; it is addressed to cultivated readers and in thoughts, ideals and outlook represents the highest achievement of his age. He became chief magistrate of Florence, and this brought him into contact with princes and even with the pope, whom he visited in 1302 in connexion with a local political feud. During his absence, enemies obtained a sentence of exile against him, with confiscation of his property and a threat of burning if captured alive. From then onwards until his death, he wandered from the court of one princeling to that of another. He had a wife, Gemma Donati, and a family; they did not accompany him into exile. He makes no mention of Gemma in his works, but, in both verse and prose, he continually revived the memory of the lady Beatrice, whom he worshipped from a distance; she was married and died young.

The 'Vita Nuova' is verse in a prose setting—or prose decked out with verse. It is a memorial to Beatrice, and relates the course of Dante's Platonic love for her. He takes each poem and explains its meaning, the whole forming a sequence of dream-like, ecstatic illusions, ending with a vision of supernatural glory and perfection. The poetry is spontaneous, the prose that of the perfect artist; the whole has a nobility and spiritual depth which immortalize it.

The 'Convivio,' or 'Banquet,' is a continuation of the 'Vita Nuova.' Beatrice becomes the symbol of Philosophy. Though incomplete, this is a beautiful work.

'The Divine Comedy.' It is, however, the stupendous achievement in 'La Divina Commedia' which places Dante in the category of Homer and Shakespeare, and makes him a successor of the poets of classical antiquity and of the Old Testament prophets. The whole work is divided into three parts: 'L'Inferno,' 'Il Purgatorio,' and 'Il Paradiso.' It is a spiritual allegory in which Virgil conducts Dante through Hell and Purgatory towards the Earthly Paradise, from which Beatrice leads him on to an anticipation of the vision of supreme beatitude in the Empyrean Heaven. Here is the whole religious philosophy of the Middle Ages presented with superb artistry, a pregnant conciseness of style, a perfect balance of thought and language, and a harmonizing of the new Italian tongue which the poet brings to complete maturity. No description can do justice to this sublime poem, for which there are as many interpretations as interpreters. Dante himself says:

DANTE. This portrait of Dante as a young man (right-hand figure) is from Giotto's fresco in the Bargello, Florence. It is the only likeness made during his lifetime. Giotto was his friend and depicts an assembly of saints among whom are the leading Florentines.

> It is to be remarked that the sense of this work is not simple, but on the contrary, I may say, manifold. For one sense is that which is derived from the letter, and another is that which is derived from the things signified by the letter: the first is called literal, the second is allegorical or moral. The subject then of the whole work taken literally is the condition of the souls after death, simply considered—on this and around this, the whole action of the work turns. But, if the work be taken allegorically, the subject is man, how by actions of merit or demerit he justly deserves reward or punishment.

What immediately strikes every reader of this incomparable work is the objectivity, the economy of style and the fullness of the images. Dante can say in a few words what another poet would take many lines to say. His achievement is all the greater because he was not satisfied to accept any existing metrical form for it, but invented his own—the wonderful *terza-rima,*—lines of ten or eleven syllables arranged in sets of three. The middle line of the first group rhymes with the first and third lines of the second, while the middle line of the second rhymes with the first and third of the third group; and so on. At the end of a canto, to round it off, there is an extra line rhyming with the middle line of the preceding group. Technically, the poem is flawless. Like the 'Iliad' and 'Odyssey,' it is an inheritance of the human race. Dante called it 'Commedia' because, in the classical tradition, every story which ends happily is a 'Comedy.'

One is tempted to dwell on this outstanding masterpiece of Italian literature, if only because its technical and artistic perfection influenced every European literature, including our own. Milton's 'Paradise Lost' may be compared with it. Dante, as Professor Garnett says, is the Seer, revealing to us his apocalyptic vision, and in this sense he is in a higher category than Milton; moreover, he is the interpreter of medieval Europe. In Garnett's opinion, Milton is the sublimer poet.

Petrarch. Francesco Petrarca (1304–74) is the greatest lyrical poet in the Italian language. His fame rests on his 'Canzoniere,' a collection of exquisite lyrics, canzoni and sonnets which bring Italian measures to their finest technical perfection. Many of these poems are dedicated to Laura, a lady whom he loved and revered from a distance, as Dante loved Beatrice.

For six centuries, Petrarch's poetry has entitled him to a place scarcely lower than that of Dante; and on a plane with Ariosto, whom we shall mention later. There is irony in his life; he hoped to achieve literary immortality by his work in Latin, particularly the unfinished epic 'Africa,' and the utmost he expected from all his writing in Italian was that it might popularize the vernacular. Little attention has been paid to his Latin, but the world acclaims his Italian poems as gems. His influence can be seen in early Elizabethan lyric poetry. Petrarch is the first great humanist of the Renaissance in Italy. As a literary figure he is more important even than Dante, though inevitably Dante dwarfs him as a poet.

Boccaccio. Giovanni Boccaccio (1313–75) is the third of this great triumvirate of Italian letters. He is famous the world over for 'Il Decamerone,' in which seven ladies and three gentlemen, to escape the horrors of the plague in Florence, retire to a house in the country and beguile the time by telling stories for a period of ten days. Highly entertaining, and at times improper, these stories are, but few of them were of Boccaccio's own invention, and the licentiousness lies in the original source.

The importance of the 'Decameron,' apart from its sheer entertainment value and the fact that it was the first work of considerable size in a perfected Italian prose, is

RENAISSANCE WRITERS. The portraits of these great figures, Petrarch (left) and Boccaccio (right), were painted by Andrea del Castagna and were originally in the convent of S. Apollonia. The two men were close friends and shared a deep admiration of Dante.

National Museum, Florence; photo, Alinari that with it modern fiction came into being. None is better than Boccaccio at telling a tale. The introductory passages are little masterpieces, characters are delineated with great skill, and the whole work is written in a narrative style which moves ahead rapidly to an inevitable and well-founded conclusion.

Boccaccio had imitators all over Europe. He became one of the most famous men of his age, chiefly because of this one book, though he wrote also two epics—' Filostrato ' and the ' Tesiad ' (or story of Theseus). Chaucer based his ' Troilus and Creseyda ' on the former, and from the latter he took his ' Knight's Tale.' Important for their influence rather than their intrinsic value, Boccaccio's ' Filicolo,' a prolix rendering of the story of Floris and Blanchefleur, is the first Italian prose romance; and ' Ameto,' a blend of verse and prose, is the first pastoral romance, a genre to be developed by Sannazaro and Montemayor (*see* below and pages 313 and 321) and by Sir Philip Sidney in his ' Arcadia.'

During the 15th century academies were founded at Florence, Rome and Naples. That at Florence, under the patronage of the Medici family, decided that the comparatively new Italian language was now, as a result of the achievements of Dante, Petrarch and Boccaccio, a full and rich literary medium, and that no writer need fear to lose caste by practising in it. This was an important landmark in Italian literature. About the same time a number of thinkers and philosophers were scrutinizing the old classical learning in a mood of criticism which heralded the Renaissance.

LESSON 11

Italian II: Renaissance to Modern Times

ITALY was the birthplace of Humanism, which took its rise in a study of the classics, and taught that man is born not only to toil and suffer but to live fully and enjoy life. The Academy at Florence fostered the study of the Latin and Greek classics, and Lorenzo de' Medici (1448–92), its rich and intelligent patron, besides encouraging others to write, was himself a graceful poet. When the German Gutenberg invented printing about the middle of the 15th century, Italy became the headquarters for the printing of all the books that mattered. Thus the Renaissance, or ' re-birth ' of learning, first took place in Italy; afterwards it spread through France into Spain, Holland, Germany, England and other countries. The importance of this movement is that it was the mainspring of our modern western culture.

It has been said that the three symbols of the Renaissance are a Latin grammar, a sailing-ship and an open Bible, signifying escape from the bonds of ignorance along three roads of progress: the Italian road of Humanism; the Portuguese road of navigation; and the German road of religious dissent. ' It was not the revival of Antiquity alone,' writes Burkhardt, the great historian of the Renaissance, ' but its union with the genius of the Italian people which, under the name of the Renaissance, achieved the conquest of the Western World.' Much of the spade-work was done by a host of patient scholars, whose work was leavened by that of a few great writers.

Early Renaissance Writers. Lorenzo de' Medici, the greatest statesman of his age, was not the least of Renaissance poets. His favourite companion, the scholarly Poliziano (1454–94), was the first to write a play in Italian on a secular subject; ' Orfeo ' is lyrical tragedy, set to music, and it is the forerunner of opera. Count Matteo Maria Boiardo (1434–94) wrote ' Orlando Innamorato,' a delightful large-scale romance of chivalry which was the highest verse achievement of the century. Orlando is better known to us as Roland, the ' preux chevalier ' of Charlemagne's court; he was also the hero of ' Morgante Maggiore,' the forerunner of modern burlesque poetry (not without its serious side), by Luigi Pulci (1432-87).

Another humorous poet who should be noted is Francesco Berni (1497–1535), who had an amazing mastery of language. Jacopo Sannazaro (*c.* 1458–1530) is famous as the author of a pastoral romance in prose and verse named ' Arcadia '; he was to number among his admirers and imitators Sir Philip Sidney and the Portuguese Ribeiro and Montemayor. In Francesco Guicciardini (1483–1540), Italy found her first great historian. He records events in Italy during his lifetime. Guicciardini was a patriot, and he was also a realist.

Baldassare Castiglione (1478–1529) wrote the famous ' Cortegiano ' or ' Courtier,' a

FAMOUS ITALIANS. *The noble portrait on the left, by Titian, is said to be that of Ariosto, who ranks near Dante. Machiavelli (right) is taken from a portrait once owned by the Ricci family, into which his daughter married.*

Portrait by Titian, National Gallery; photo, E.N.A.

picture of high society in excellent prose. From Giorgio Vasari (1512–74) came the 'Lives of Great Painters,' and Benvenuto Cellini (1500–71) has given us one of the few great autobiographies in literature, a work of absorbing interest that bears the stamp of objective truth.

Machiavelli. Few writers have been more disliked than the Florentine, Niccolò Machiavelli (1469–1527). Modern scholarship tends to show that injustice has been done to this man, who was the originator of modern political science. His best-known work is 'Il Principe' ('The Prince'), which should be read in conjunction with his 'Discourses on the First Decade of Titus Livius,' from which it is a development. 'The Art of War' is a practical treatise. 'The History of Florence' is commentary rather than history.

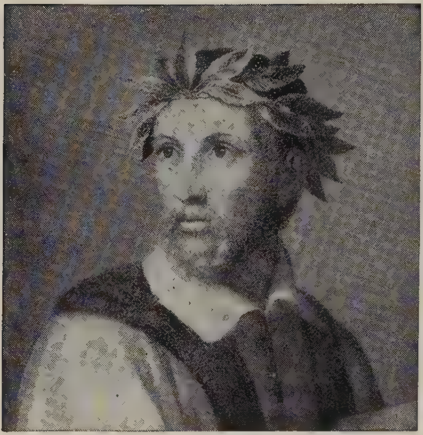
Machiavelli was the son of a learned jurist and a poetess, and he seems to have inherited the scholarship of his father together with the literary ability of his mother. While still young he entered diplomatic life and rose to the high office of Secretary of the Republic. He travelled on various missions and spent some time with Cesare Borgia, whom he idealizes. He has been depicted as a cunning intriguer bereft of morality, but it is now realized that he was not an enemy of freedom for the people, and that his political writings were concerned chiefly with ways and means of clearing away the feudalistic anarchy around him and putting in its place a State which would give the people a fair deal. To show his compatriots how far they had abandoned the path of their forefathers, and to draw mankind from the evils caused by proud indolence and lack of true historical knowledge, he wrote the 'Discourses,' which modern critics tend to regard as more important than 'The Prince.'

Machiavelli looked for the regeneration of Italy, the expulsion of the foreigner and the establishment of a strong, unified rule. It was precisely because he not only advocated these aims, but showed in the clearest of terms how they could be achieved, that he incurred the enmity of an important section of the Church and of all Europe that was hostile to Italy.

As a solution of his main problem, he imagined a prince as figurehead, surrounded by wise and determined advisers who would stop at nothing in their struggle to achieve freedom and good administration. All this was understood by those who had the country's interests at heart and, if one admits that the aims were good and honest, then Machiavelli's work must be similarly regarded. But, regarded from another angle, 'The Prince' may seem a diabolical book, a manual for unscrupulous tyrants. And indeed this is what it too often became. It is said to have been carefully studied by, among others, Napoleon, Hitler and Mussolini, dictators all.

Not only is Machiavelli among the great political thinkers of the world, and the first to appreciate and to put into words the potency of the national idea, but he was also an accomplished poet and playwright. His comedy 'Mandragola,' though unpleasant in plot, is one of the most brilliant in Italian literature. Everything he wrote is in a scintillating style of singular lucidity, of powerful simplicity. At times it is capable of great eloquence and dignity.

Ariosto. In the same period lived Ludovico Ariosto (1474–1533), whose 'Orlando Furioso' is an imperishable work of poetic imagination which places him next after Dante among Italian poets. This romantic epic shows, as a subsidiary episode, Orlando (Roland) being driven mad (*furioso*) by his unrequited love for the lady Angelica, who loves and is beloved by his friend Rinaldo. It is, in a sense, a sequel to the 'Orlando Innamorato' of Boiardo, but we have now a master-craftsman elaborating the theme, in a succession of thrilling episodes of chivalry. The interest is shifted to a new



TASSO. This great poet, though handicapped by uneasy circumstances which caused mental instability, nevertheless produced the splendid epic, 'Jerusalem Delivered.' His exquisite 'Aminta,' a pastoral drama, was a forerunner of opera.

pair of lovers, from whom the house of Este, whom the poem glorifies, traced their descent. Spenser's 'Faery Queene' is much indebted to Ariosto, and he also had many imitators in his own country.

Tasso. From Ariosto to Torquato Tasso (1544–95) is not a great step in time. Tasso's 'Gerusalemme Liberata,' dealing with the capture of Jerusalem by the Crusaders, is a chivalrous epic which glorifies Italy as the centre of Catholic Christendom. Essentially a Renaissance product, a poem of civilization, it deservedly achieved an immediate and widespread success because of the simplicity and beauty of its diction and its high moral tone. Controversy has arisen as to whether Tasso or Ariosto was the greater poet; Christian moralists usually prefer Tasso's work, literary critics that of Ariosto. Suffice it to say that both 'Orlando Furioso' and 'Gerusalemme Liberata' are masterpieces.

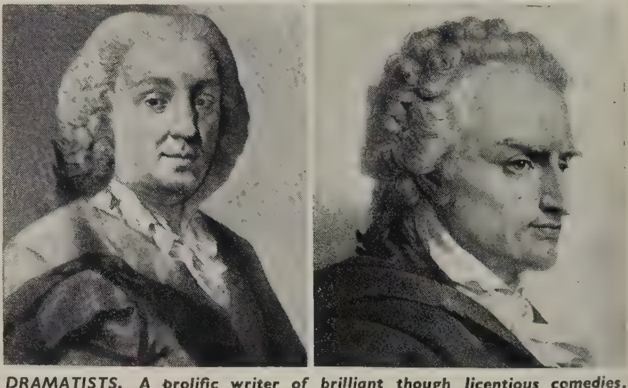
Tasso's genius first revealed itself at the age of 18, when he produced a romantic epic, 'Rinaldo,' inspired by Boiardo and Ariosto. Later, he wrote the exquisite 'Aminta,' which is the first important pastoral drama in poetry and had a deep influence on the development of opera. It is the most easily appreciated of his works.

Rise of Drama. Passing over the uneventful 17th century, we find that the 18th is notable chiefly for the rise of drama. The old *commedia dell' arte*, or comedy of masks, had persisted from the time of the Romans; they had inherited it from the Greek countryfolk who worshipped the wine-god Dionysus with mime and song. The stories were traditional and there were stock characters, including Columbine, Harlequin, Pantaloon and Punchinello: the speeches were often impromptu. Count Carlo Gozzi (1720–1806), in a brilliant series of fairy-tale fantasies, embodied the true spirit of the commedia dell' arte, which had never before taken literary shape.

Meanwhile, the musical drama had begun in earnest with Pietro Metastasio (1698–1782), in whom the qualities of poet and dramatist were happily blended. Among his many plays, the most successful were 'Achille in Sciro,' 'Clemenza di Tito,' and 'Attilio Regolo.'

Goldoni and Alfieri. The first Italian dramatists to achieve a European reputation were Carlo Goldoni (1707–93) and Count Vittorio Alfieri (1749–1803). Goldoni drew his characters from life, providing them with witty and vivacious dialogue. Of his famous comedies, the best known are 'La Bottega di Caffè,' 'Pamela Nubile,' 'Gli Innamorati,' 'Il Bugiardo' and 'La Locandiera.'

Alfieri is the greater dramatist and he was also, in his passionate desire for liberty, the



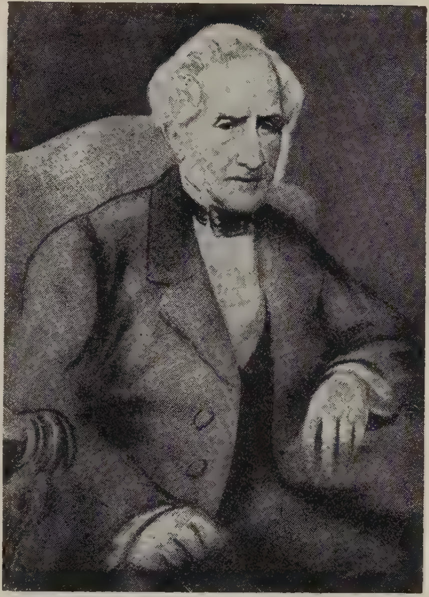
DRAMATISTS. A prolific writer of brilliant though licentious comedies, Goldoni (left) depicted Venetian life. He afterwards settled in Paris, where he enjoyed royal favour. The powerful tragedies of Alfieri (right) were inspired by patriotic and revolutionary fervour. He eloped with the wife of the ageing Young Pretender and afterwards married her.

herald of a new Italy. He wrote a score of tragedies inspired by the revolutionary spirit; outstanding are 'Saul,' 'Myrrha,' 'Abel,' 'Philip the Second' and 'The Conspiracy of the Pazzi.' Alfieri's autobiography is both a work of art and a masterpiece of self-analysis.

19th Century Poets and Novelists. The 19th is not a great century for Italian literature, though it produced many works of interest. The French Revolution had suggested new themes and aroused vehement passions. The poet Vincenzo Monti (1754–1828) reflects the fluctuating emotions of his day. With the publication of 'Bassvilliana,' Monti was recognized as the best epic poet of the period; the murder of the unimportant French diplomat Bassville is the pretext for a denunciation of the Terror. Monti was an impressionable man, one day swayed by the passions of the moment, and next day capable of a Dantesque objectivity. He wrote thundering verse against superstition, and impressive odes in favour of Italian unity. The only two names which can be mentioned with that of Monti are Ugo Foscolo (1778–1827) and Ippolito Pindemonte (1754–1825), lesser poets but not unimportant.

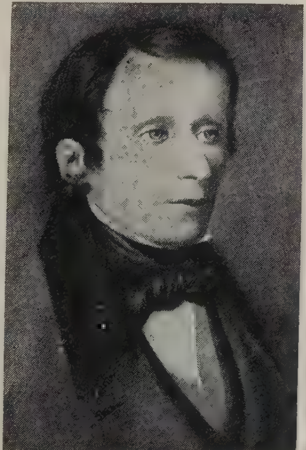
German Romanticism and the pessimism which is a frequent reaction after thrilling events had a considerable effect on 19th century Italian writers. Count Alessandro Manzoni (1785–1873) is the greatest Romantic novelist of Italian literature. As a religious man and reactionary, he is an antidote to the scepticism and liberalism of Monti and Foscolo. Manzoni wrote fine poetry, two remarkable tragedies and a number of moralistic essays. But it was his great novel 'I Promessi Sposi' ('The Betrothed') which established his fame (1825–27). The theme is simplicity itself: the love of Renzo and Lucia interwoven with the tragic story of a nun against a colourful 17th century background.

The book is so charged with Romanticism and sentimentality that today it would be almost unreadable but for certain qualities which it undoubtedly possesses. First, Manzoni's characterization is often magnificent and shows especial sympathy for the unfortunate. Second, his style is admirable, though the historical element is not perfectly assimilated. Third, he is one of the best Italian humorists, and has a gift of irony. The final and thoroughly revised edition of 'I Promessi Sposi' was published in 1840–42; since then it has been the best known Italian novel.



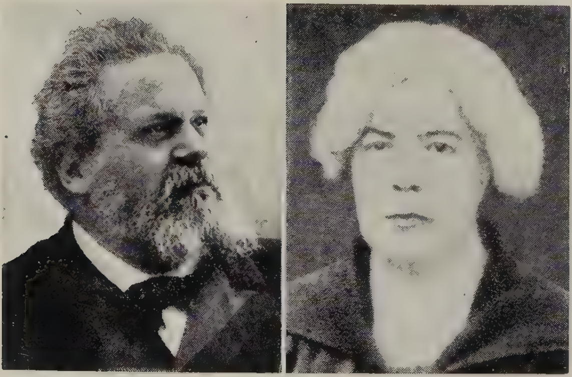
MANZONI. *Author of the most celebrated Italian novel, 'I Promessi Sposi,' Manzoni was also a Romantic playwright and poet, who led a reaction to medievalism. He won the admiration of Goethe, and Verdi's 'Requiem' was dedicated to his memory.*

Photo, E.N.A.



LEOPARDI. *The pessimism of this superb poet is understandable. He was a cripple, often in pain, with failing eyesight, and also suffered from poverty.*

Count Giacomo Leopardi (1798–1837) is the greatest Italian poet since Tasso; as a lyricist, he is supreme, and his blank verse is unequalled; he is also the master of a beautiful prose style, seen in his essays, dialogues, letters and aphorisms. It was said that he lived pessimism; do what he might, it seeped into all his works. A Romantic, he has affinities with



MODERN WRITERS. *First and greatest of the modern poets, Carducci (left) gave classical form to revolutionary ideas, notably in his 'Hymn to Satan.' He was Professor of Literature at Bologna and won the Nobel Prize in 1906. The novelist Grazia Deledda (right), a native of Sardinia, was Nobel Prizewinner in 1926.*

Photos, E.N.A.

Byron, whom he enthusiastically admired. Leopardi's works are not at all numerous, but they approach, and often attain, perfection. His influence has been profound.

Contrast is provided by Giuseppe Giusti (1809–50), whom it is customary to regard as the Italian counterpart of Béranger. He excelled in satire, writing in an easy humorous style, usually in the Tuscan dialect. This, as with our own Burns, makes him difficult for the foreigner to appreciate. Gioacchino Belli (1791–1863) is similarly obscure; he used the Roman dialect to depict the life of contemporary Rome in some 2,000 sonnets, each a lively miniature.

In drama, Giovanni Battista Niccolini (1782–1861) is the outstanding figure. His tragedies are infused with a noble patriotism and idealism. 'Arnaldo di Brescia,' his finest work, is a challenge to the Papal power, poetic rather than dramatic; it was never intended for the stage, and is overlong to be performed. 'Antonio Foscarini' is the most successful of his other plays. Silvio Pellico (1788-1854) is remembered for one moving autobiographical volume, 'Le Mie Prigioni,' and for his tender 'Francesca da Rimini'; he wrote many other plays.

During the same period, Giuseppe Mazzini (1805–72) wrote on political subjects, as one would expect of this noble patriot; and also on the arts. He was deeply religious, and the rare element of mysticism is present in all his thought. Another political writer was the wise priest, Vincenzo Gioberti (1801–52), a Platonic idealist who endeavoured to reconcile science and religion.

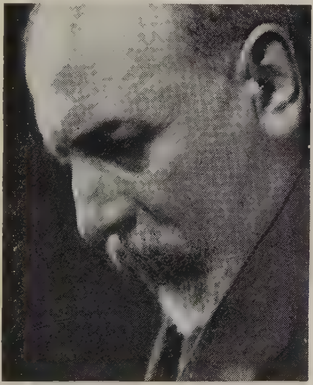
Advent of the Moderns. Most important as the forerunner of the modern school was Giosuè Carducci (1836–1907), in whom we find the best qualities of classicism and romanticism combined—dignity and shapeliness invigorated by enthusiasm and original thought. He wrote noble poems and scholarly prose. Giovanni Pascoli (1855–1912), though uneven, rose to occasional greatness and was deservedly popular.

Among the novelists, Antonio Fogazzaro (1842–1911) wrote with a sense of spiritual values, under the influence of Manzoni. 'Piccolo mondo antico,' 'Il Santo' and 'Daniele Cortis' are his most notable books. Better known to us is Giovanni Verga (1840–1922), the Sicilian novelist. The powerful 'I Malavoglia' and 'Maestro Don Gesualdo,' and many of his sketches and short stories, including 'Cavalleria Rusticana,' have been beautifully translated by D. H. Lawrence. Matilde Serao (1856–1927) has been very popular; 'Il paese di Cuccagna,' 'Il ventre di Napoli' and 'Fantasia' are her best novels, written in impressionistic style. Grazia Deledda (1875–1936) has written vivid stories with a Sardinian background, notably 'Il vecchio della montagna' (1900) and 'Cenere' (1903). Her later works include 'La Madre' (1920) and 'Il Tesoro' (1928).

D'ANNUNZIO. *Best known of modern Italian writers is this brilliant novelist, playwright and poet. He led a daring raid on Fiume in 1919 and annexed it in his country's name; though disclaimed and dislodged, he was rewarded by the title of Prince.*

D'Annunzio. In contemporary Italian literature, the picturesque figure of Gabriele d'Annunzio (1863–1938), Prince of Montenevoso, towers over all others. His sensational behaviour and decadent tastes kept him in the eyes of the public, and would have been detrimental to his reputation as a serious writer, if it were not for the real merit of his work. Brilliant alike in verse and prose, though it has been objected that he is wanting in the creative gift, d'Annunzio revivified Italian literature.

His first volume of verse, 'Primo Vere' (1879), appeared while he was still a schoolboy and was highly praised. 'Canto Nuovo' (1882) and 'Terra Vergine' (1883) contained lyrics of intoxicating beauty and passion. In 'Intermezzo di Rime' (1884), d'Annunzio showed a voluptuousness which some of his critics regarded as an unworthy influence. Some of his later volumes were inspired by patriotic fervour. Unfailingly he showed the perfection of his lyric gift. He invented the 'rima nona,' an Italian variant of the Spenserian stanza. It was, indeed, his instinct for formal beauty which, generally speaking, curbed the luxuriance of his imagination and saved him from mere extravagance.


PIRANDELLO. A world-famous dramatist, this great Sicilian is highly original. He began by writing poetry, novels and short stories.

He turned to play-writing in 1897, with a one-act fantasia. 'La Città morta,' a tragedy in the classic manner, was written for Sarah Bernhardt, and 'La Gioconda' (1898) for Eleanora Duse. His finest work, however, is in the magnificent 'Francesca da Rimini' (1902) and the rustic tragedy, 'La Figlia di Jorio' (1904). He wrote in French 'Le Martyre de St. Sébastian' (1911), for which Debussy composed the music, and later, 'Parisina' (1914) with music by Massenet.

D'Annunzio's novels had a somewhat wider public than his poems and plays. Starting in 1889 with 'Il Piacero' ('The Child of Pleasure'), he made a sensation which was repeated with 'L'Innocente' (known to us as 'The Intruder'), 'Giovanni Episcopo,' 'Il Trionfo della Morte,' 'Le Vergini delle Rocce' and 'Il Fuoco.' Later 'Forse che sì, forse che no' (1910) showed the author's interest in aviation. 'La Nave' (1908) is non-fictional propaganda, urging Italy's development as a sea-power.

This author's amazing versatility is manifest. In addition to his output as poet, dramatist, novelist and propagandist, he wrote short stories, journalistic articles and treatises. His autobiography appeared in 1935. Altogether his published works amount to 64 volumes. These, it should be remembered, were the work of a man who led a very full life, in his early days as a man of pleasure and later as an active careerist. His fervent patriotism led him to take service in the army, both with the cavalry and with the infantry, then in the navy, and finally in the air force. He was politically a firebrand, and it was natural that Fascism should find in him an enthusiastic supporter.

Pirandello. Less colourful but more influential outside his own country, Luigi Pirandello (1867–1936) was one of the world's most original dramatists. A Sicilian, he became a schoolmaster and wrote verse, short stories and novels which had a restricted appeal. He began writing plays in 1912, with moderate success, but it was not until 1921 that he achieved his reputation with 'Six Characters in Search of an Author' (depicted in Drama Course, Vol. II, p. 15), which was translated into many languages and played all over the world. Best known of his other plays are 'Henry IV' and 'As You Desire Me.' He also wrote one-act dramas; 'The Man With a Flower in his Mouth' is most poignant. In 1925 he founded his own theatre in Rome and took his plays on tour in Europe. Their success created a public for his novels, of which 'The Outcast,' 'One, None and Ten Thousand' and 'The Naked Truth' should be noted. Of his short stories, a selection is available in English translation, in a volume entitled 'Better Think Twice About It.' In 1934 Pirandello was awarded the Nobel Prize.

Though his thought and technique are fascinating, Pirandello will never be popular; he is too intellectual.. Many of his characters have no supposedly human existence and are mere abstract projections of the author's thought.

Modern poetry has been influenced by Filippo Marinetti (b. 1878), who founded Futurism in 1909.

Modern Thinkers. The far-reaching influence of Benedetto Croce (b. 1866) has been an important factor in modern thought. Certain it is that he stands head and shoulders above his contemporaries in the interpretation of history, in criticism and in philosophy. His 'Aesthetic' is a fundamental work and expounds his famous theory that all art is akin to lyrical intuition; that art criticism consists in ascertaining to what extent the work of art represents genuine intuition; that literary history consists of a collection of 'essays' on individual aesthetic problems. This work and that of Giovanni Gentile (b. 1875) are two of the highest peaks in the philosophy of interpretation. Gentile's particular contribution is his 'Theory of the Mind as Pure Art.' Like Croce, he was influenced by Hegel. As minister of education, he carried out sweeping reforms which he discusses in his book, 'The Reform of Education.' He became a strong supporter of Fascism.

CROCE. A most prolific writer, Benedetto Croce devoted himself mainly to philosophy. He was a leader of liberal thought in Italy before and after Mussolini's fall.

The Fascist revolution dried up the springs of literary inspiration and, apart from the work of the older writers we have noted, there is nothing worthy of record between 1920 and the Second World War. We must wait until the country is well settled after the Second World War before we can expect that second Renaissance of letters which is overdue. That it will come need not be doubted, for Italy has again and again shown that she is capable of rising to the heights of intellectual achievement.

LESSON 12

German I: Early Times to Classical Period

GERMAN literature goes back to a period of Old High German which began in the 8th and ended in the 11th century. Then came the Middle High German (or Medieval) period lasting until the 16th century, followed by the Modern High German period, which may be subdivided into an early period, sometimes called the German Renaissance, lasting up to the end of the 17th century, the Classical period, occupying the 18th century, the Romantic period of the early 19th century, and the late period.

From the Old High German period, only a small amount of religious literature and some fragmentary lays remain.

Early Medieval Literature. The Middle period saw the rise of the Spielmann, or wandering singer, through whom a secular literature came into being. This literature took three main forms: the national (or popular) epic, the court epic, and the lyric, or Minnesang. At first the influence of French literature was strong; the 'Chanson de Roland,' the 'Chanson d'Alexandre,' the Tristan story, the 'Roman de Renart' and many other French poems appeared in German versions. The first purely German popular epic was 'König Rother' (*c.* 1160), which, like much of contemporary literature throughout Europe, introduced scenes from the Orient, inspired by the Crusades.

The Nibelungenlied. Among the world's very greatest epics is the 'Nibelungenlied' ('Lay of the Nibelungs'), which dates from the end of the 11th century. The mighty vigour, the splendid imagination, the moving simplicity of this vast poem, have made it Germany's outstanding contribution to medieval literature. The story, based on various sagas which deal with the hero Siegfried, has become familiar to us through Wagner's 'Ring' cycle. Overpowering passions, treachery and revenge, make up a sombre picture, lit with flashes of beauty.

Complementary to the 'Nibelungenlied' is the epic of 'Gudrun,' and there is also a group known as the 'Heldenbuch,' based on old sagas which had Dietrich (Theodoric the Goth) as hero.

Romances and Lyrics. The court epic, similar to the French 'roman courtois,' centred round the Arthurian legends. Hartmann von der Aue, Wolfram von Eschenbach and Gottfried von Strassburg were the most important poets. Hartmann, under the influence of Chrétien de Troyes, wrote 'Der arme Heinrich' and 'Iwein,' fresh and shapely romances. Wolfram, author of the profoundly moving 'Parzival' (about 25,000 lines), is the greatest of medieval German poets and the greatest European poet before Dante. Gottfried's 'Tristan' is another masterpiece of medieval literature.

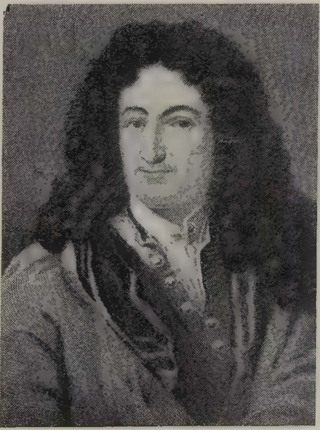
The Minnesang was derived from the Provençal lyric in form and content. Notable among the Minnesingers was Walther von der Vogelweide (*c.* 1170–*c.* 1228), who is, indeed, one of the greatest of all lyric poets, excelling in love-songs. His 'Unter den Linden' is among the treasures of medieval Germany.

Later, the courtly Minnesingers were replaced by the Meistersingers, who learned their art in schools, according to formula. They were unable to restrain the spontaneous growth of the Volkslied, those lovely musical folk-lyrics which persist throughout German literature. In quite another vein, the most famous satire of its period, the 'Narrenschiff' of Sebastian Brandt (1458-1521), appeared in 1494 and set the example for Alexander Barclay's 'Ship of Fools' and countless other imitations.

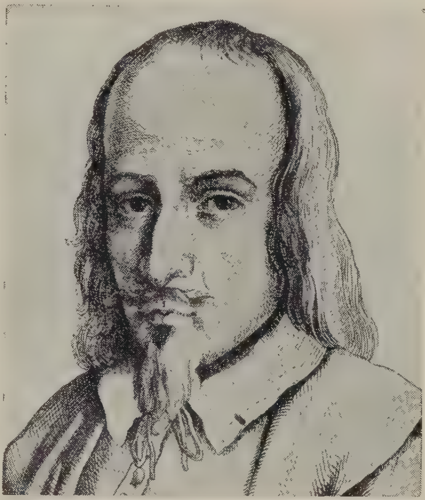
In prose, the Schwank, or humorous anecdote, was most popular; sometimes a number of these were collected round a central figure, as in 'Tyl Eulenspiegel' (1515). Beast fables were also common; 'Reinke de Vos,' a version of the 'Roman de Renart,' appeared in 1498.

Religious Writings. As we approach the Reformation period, religious thought comes to the fore. Mysticism in Germany began with Meister Eckhardt (*c.* 1260–*c.* 1327), and gathered strength. Its essence was an intensely personal communion with God, and it therefore contributed to the Protestant Reformation, in requiring that the Bible should be made accessible in the mother-tongue. The first translation from the Vulgate into German was published in 1466.

Germany's greatest man at this period was Martin Luther (1483–1546), who translated the Bible into the pithy language of the common people, embodying the results of the New Learning (*see* Modern History Course, Vol. VI, pp. 3–6). He also compiled a Protestant hymnal, in which he included many hymns of his own composition, notably 'Now thank we all our God.' Luther wrote the most important of the polemical treatises on the Protestant side. The Catholic side had a doughty champion in the Franciscan scholar Thomas Murner (1475–1537), most brutal of satirists.



LEIBNITZ. *The philosopher Leibnitz, a trained mathematician, discriminated between Reality and Appearance, holding that Reality is a harmonious whole in which all elements play their part.*



BÖHME. *This gentle Quietist was a shoemaker who had mystical experiences. He taught that man should seek oneness with God and the universe through quiescence.*

From Beckstein, Deutsche Männe

The German Renaissance. Drama flourished during the latter part of the Medieval period, manifesting itself chiefly as scholastic comedy based on Latin models and as the Fastnachtsspiel, or Shrovetide play, a brief episode with a moral lesson, often treated humorously. Hans Sachs (1494–1576), a cobbler of Nuremberg, had a very considerable output of verse and drama, and was especially happy in his Shrovetide plays.

There was a recrudescence of mysticism in the philosophy of Jakob Böhme (1575-1624), whose influence is seen in the poet

Johann Scheffler (1624–77) and later in our own William Blake. The Jesuit Friedrich von Spee (1591–1635) and the Lutheran Paul Gerhardt (1607–76) were among those who contributed most to the religious poetry which is the glory of the 17th century—the German Renaissance.

A most important contemporary figure was Martin Opitz (1597–1639), whose 'Buch von der deutschen Poeterey' (1624) formalized German poetry as Boileau was later to formalize the French. By his many translations, Opitz brought Germany into the main stream of late Renaissance culture.

The novel had originated in the 15th-century Volksbuch, of which the 'Historie von D. Johannen Fausten' is the most interesting example. In the 17th century, Spanish influence was supreme; the first of the Spanish picaresque novels, 'Lazarillo de Tormes,' was translated in 1617 and 'Don Quixote' in 1625. The greatest German novel of the century is 'Der abenteuerliche Simplicissimus,' by Hans Jakob Christoffel von Grimmelshausen (*c.* 1624–76). Later we have, for a short time, the influence of Góngora, and in the early years of the 18th century English literature became popular. 'The Tatler,' 'The Spectator' and 'The Guardian' were translated and imitated, as was 'Robinson Crusoe.' The critic Johann Christoph Gottsched (1700–66) tried to impose the standards of the French classicists, but English naturalism triumphed and brought the German Renaissance belatedly to its close.

The first great German philosopher, Gottfried Wilhelm Leibnitz (1646–1716) contributed much to the growth of rationalism, which was one of the characteristics of the Classical Age; but he wrote mostly in French and Latin.

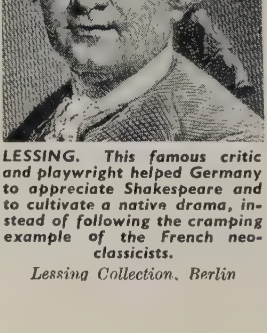
LESSON 13

German II: The Age of Goethe

GERMANY's classical age derived much of its inspiration directly from the Greek classics, but it was also open to English influences; its admiration for Shakespeare always far exceeded its admiration for the French classical dramatists.

The Rise of Classicism. Friedrich Gottlieb Klopstock (1724–1803) was the first great poet of modern German literature. His vast religious work 'Der Messias,' inspired by Milton's 'Paradise Lost,' appeared in parts (1748–73); on this his immediate reputation was founded. But it is as a lyric poet that Klopstock is important; his odes are truly national and his lyrics have the personal note which was a Romantic characteristic. He was also a notable dramatist: three of his plays, influenced by the translation of Macpherson's 'Ossian,' glorify the early patriot, Hermann.

Klopstock was followed by Christoph Martin Wieland (1733–1813), poet, playwright and novelist, whose 'Agathon' (1767) is the first modern German novel; written under the influence of Richardson, it shows the hero's psychological development against a classic background. Wieland's best known work is the epic 'Oberon' (1780), a rendering of the old French romance 'Huon de Bordeaux,' with additions from Chaucer and Shakespeare.



LESSING. *This famous critic and playwright helped Germany to appreciate Shakespeare and to cultivate a native drama, instead of following the cramping example of the French neo-classicists.*

Lessing Collection, Berlin

Gotthold Ephraim Lessing (1729–81) will always be remembered for his unfinished critical essay 'Laokoon' (1766), an attempt to define the spheres of poetry and the plastic arts. Of his plays, 'Minna von Barnhelm' (1763) is the first great comedy in the German language. Lessing was a philosopher and a theologian; he did much to establish nationalism in Germany, and thus helped to inaugurate the classical period. His influence extended throughout Europe.

Gottfried Herder (1744-1803), a profound thinker, had one of the most original minds of his day. In 1773 he wrote, as the manifesto of the 'Sturm und Drang' (storm and stress) movement, directly influenced by Rousseau, 'Von deutschen Art und Kunst.' This movement was preluded by the 'Göttinger Dichterbund,' a group of poets of whom Gottfried August Bürger, the famous ballad writer (1747–94), was the chief. Bürger's 'Lenore' became known throughout Europe and influenced, among others, Sir Walter Scott. The interest in balladry was further stimulated by Herder's valuable collection of 'Volkslieder' from all nations.

Goethe. The great figure of his age was Johann Wolfgang von Goethe (1749–1832). Herder had helped to impart the knowledge of Shakespeare's works to which this supreme genius owed so much. Outside Germany, Goethe's reputation rests chiefly on his tremendous drama 'Faust' (first part, 1808; second, 1832), which ranges over time and space, illuminating every scene with its magnificent poetry and noble philosophy.

SCHILLER. Arriving at Weimar in 1787, Schiller eventually became the friend of Goethe. A superb poet, he was also the supreme dramatist of his age.

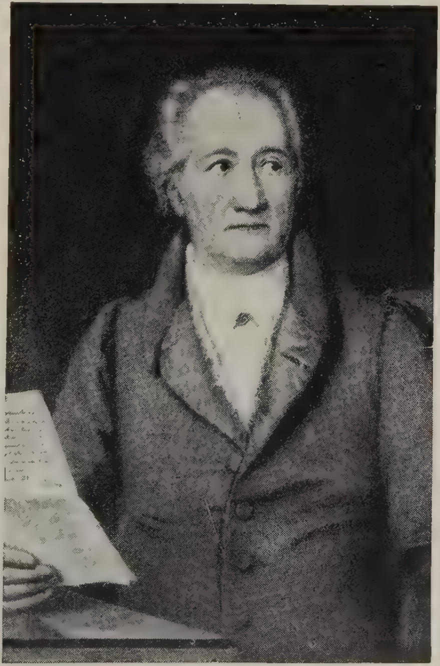
Painting by Frau Ludovika Simanovitz

Goethe's works embrace almost every form of literature: essays, novels, poetry, history, drama, criticism. In this period of 'Sturm und Drang,' when writers and philosophers were endeavouring to find solutions for the problems of life, it was Goethe who gave shape to the surging individualistic revolt, begun by Rousseau, against the institutionalized state. He dominated German thought during the classical period.

Goethe's genius was first revealed in lyric poetry; the 'Sesenheimer Lieder' and the impassioned 'Wanderers Sturmlied' are deeply emotional masterpieces. Then came a powerful play influenced by Shakespeare—'Götz von Berlinchingen'—(1773) and the sentimental novel, 'Werthers Leiden,' known in English as 'The Sorrows of Werther' (1774), which became popular throughout Europe. In Italy Goethe wrote 'Iphigenie auf Tauris' (1787), a superb adaptation of Euripides, which, with 'Egmont' (1788) and 'Torquato Tasso' (1790), make up a trio of great dramas.

'Wilhelm Meisters Lehrjahre' (1795–96) is a novel of serious purpose, showing, with a wealth of interest, how a romantically-minded young man learned to adapt himself to life. Years later, Goethe continued it, in 'Wilhelm Meisters Wanderjahre' (1821–29). As precursor of the Romantic novel, 'Wilhelm Meister' had a very great influence throughout Europe. Of his other works, the idyllic 'Hermann und Dorothea' (1798), a narrative poem in hexameters, has a simple perfection, and the novel 'Die Wahlverwandtschaften' (1809), is a psychological study in the classical manner.

Schiller. Second only to Goethe in importance is Johann C. Friedrich von Schiller (1759–1805), whose first play, 'Die Räuber' (1781), a moving tragedy, embodies the spirit of 'Sturm und Drang.' By 1782 he had also established himself as an outstanding lyric poet. He excelled in philosophic lyrics and in ballads; the glorious 'Lied von der Glocke' (1799) is his highest achievement in poetry. Of Schiller's many



GOETHE. A noble humanism pervades Goethe's work and his own life. Practical wisdom in him was warmed by benevolence. He held various important posts at the Duke of Weimar's court.

plays, 'Kabale und Liebe' (1784) was the first great tragedy of love in German drama, and 'Don Carlos' (1787) was a striking plea for freedom of thought. Schiller's dramatic masterpieces, however, are the 'Wallenstein' trilogy, 'Maria Stuart,' 'Die Jungfrau von Orleans,' 'Die Braut von Messina' (written in the manner of Greek tragedy) and 'Wilhelm Tell'; these were his later work, from 1798 onwards.

As a critic, Schiller is most interesting in his 'Über naive und sentimentalische Dichtung' (1795–96), in which he divided literature into two groups—the 'naïve,' such as is found in natural poetry and in the work of great geniuses like Shakespeare, and the 'sentimental,' which does not create but gives shape to things already in existence, comments upon them and inspires them with feeling. Schiller regards Goethe as a 'naïve' genius and himself as one of the sentimentalists. In other treatises on aesthetics he supplemented the theories of Kant. 'Über Anmut und Würde' is a plea for graciousness and dignity in life.

Kant. The greatest philosopher since Descartes, Immanuel Kant (1724–1804) was a rationalist who taught submission to the moral law. The 'Kritik der reinen Vernunft' ('Critique of Pure Reason') is his best known treatise (1781). Kant had a tonic effect: through his influence, a new and practical idealism came into being (*see further* under Philosophy, Vol. V, Lesson 9). Johann Gottlieb Fichte (1762–1814) was his most important disciple; and Friedrich von Schelling (1775–1854) expressed the metaphysical doctrines of Romanticism.

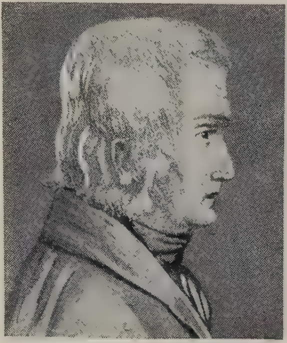
New Romantic Era. With the 18th century ended the great period of classical German literature, during which the traditional classical forms had been observed and the language was at its purest.

The Romantic revival was, like the earlier 'Sturm und Drang' movement, strongly individual; it did not, like its predecessor, simply break down barriers, but presented a new conception of life as a unified whole, made beautiful by nature and the arts.

One of the earliest romantics was Friedrich Hölderlin (1770–1843), an extraordinarily gifted lyric poet who found his inspiration in ancient Greece. Hölderlin, a passionate idealist, wrote splendid, though obscure, odes and hymns which have affinities with the 'Prophetic Books' of William Blake; 'Patmos' is outstanding among them. His rhapsodic novel, 'Hyperion,' is also noteworthy. General disillusionment and depression drove him towards insanity, and the early death of the woman he had hopelessly loved came as a final blow; the greater part of the last forty years of his life was spent in an asylum. His work was overlooked until Stefan George revived interest in it, but he has recently been acclaimed as one of the most inspired of German poets.

KANT. A saddler's son of Scottish descent, Kant had a long struggle with poverty. He became Professor of Logic and Metaphysics at Königsberg, his native town, in 1770. He led a rigorously ascetic life.

From Könnecke: Bilderatlas zur Geschichte der Deutschen Nationallitteratur



HÖLDERLIN. An early Romantic, Hölderlin was hyper-sensitive and introspective. He wrote little, but it is of exquisite quality, akin to Blake's mystical poems.

Photo, E.N.A.

In 1798 a little group of romantic writers was formed, its chief members being Friedrich von Hardenberg (1772–1801), who wrote as 'Novalis,' Ludwig Tieck (1773–1853), W. H. Wackenroder (1773–98), August Wilhelm Schlegel (1767–1845) and his brother Friedrich (1772-1829).

Novalis was a mystic whose genius finds supreme expression in his ‘ Hymnen an die Nacht,’ the rhapsodic prose of ‘ Die Lehrlinge zu Sais ’ and the faery romance, ‘ Heinrich von Ofterdingen.’ Tieck wrote romantic dramas which are poetic rather than dramatic; he was influenced by Calderón. He was also a novelist; the early ‘ William Lovell ’ is Werther-ish, ‘ Franz Sternbald ’ (1798) and ‘ Der junge Tischlermeister ’ (1836) are in the ‘ Wilhelm Meister ’ spirit, and ‘ Der Aufruhr in den Cevennen ’ (1826) is an excellent historical novel, showing the influence of Scott, which was prevalent throughout Europe at this time. Tieck's ‘ Novellen ’ (short stories) and ‘ Märchen ’ (fairy tales) should also be remembered. Wackenroder, who was Tieck's friend, wrote a stimulating little book on the arts. The Schlegels had a European reputation as critics and produced many volumes of essays. August began the translation of Shakespeare; he also translated Calderón.

A second Romantic school, known as the Heidelberg group, was founded by Klemens Maria Brentano (1778–1842), Ludwig Achim von Arnim (1781–1831), and J. J. von Görres (1776–1848), with whom the Grimm brothers, Jakob (1785–1863) and Wilhelm (1786–1859) were associated. Brentano and Arnim made an excellent collection of German Volkslieder in ‘ Der Knaber Wunderhorn ’ (1805–8); its effect is seen in lyric poetry throughout the century. The Grimms, world-famous for their ‘ Märchen,’ were scholarly philologists.

This group soon broke up; Brentano and Arnim founded a new circle in Berlin. Brentano wrote the beautiful allegory, ‘ Romanzen von Rosencranz ’ (1852), and Arnim developed as a historical novelist. They were now associated with Adelbert von Chamisso (1781–1838), who came of an exiled French aristocratic family and was one of the most delightful lyric poets writing in German; he was author, too, of the popular ‘ Peter Schlemihls wundersame Geschichte ’ (1814), the fantastic story of the man who lost his shadow.

Other notable Romantics were Baron Joseph von Eichendorff (1788–1857), a lyric poet with a true love of nature, who was also a novelist, author of ‘ Aus dem Leben eines Taugenichts ’ (translated as ‘ Memoirs of a Good-for-Nothing ’); Ludwig Uhland (1787–1862), famous as a ballad-writer in the true Volkslied tradition; the Austrian Nicolaus von Strehlenau, or Lenau (1802–50), a superb though pessimistic lyric poet; Friedrich Rückert (1788–1866), a consummate artist, who drew his inspiration from oriental studies; Wilhelm Müller (1794–1827), one of the champions of Greek independence, who wrote a surprising amount of lovely and sincere verse; the Swabian Eduard Mörike (1804–75), whose lyrics have a restraint and simplicity which sets them apart; and Annette von Dröste-Hülshoff (1797–1848), who wrote a splendid epic of the Thirty Years' War, besides nature poetry and religious poetry of real insight.

In drama, the chief figures were Zacharias Werner (1768–1823), whose somewhat turgid plays combine historic and religious interest; Heinrich von Kleist (1777–1811), a great dramatic poet who was also a novelist; and Franz Grillparzer (1791–1872), an Austrian, many of whose masterpieces are based on themes from the Greek classics or from German history. Karl Immermann (1796–1840) experimented in many kinds of drama and poetry; his most memorable work is the dramatic poem ‘ Merlin.’ Linked with drama, we must remember the opera, in which at this time we have the illustrious names of Gluck, Mozart, Beethoven (‘Fidelio ’), Weber, Meyerbeer and Wagner.

The Romantic Novel. Of Romantic novelists, Ernst Theodor Wilhelm Hoffmann (1776–1822) is outstanding. In ‘ Die Eliziere des Teufels,’ ‘ Phantasiestücke,’ ‘ Nachtstücke,’ and ‘ Klein Zaches ’ he revived the tale of terror which Monk Lewis had begun in England; he also wrote stories of a more normal kind, such as ‘ Das Fräulein von Scuderi ’ and the humorous ‘ Kater Marr.’ Friedrich de la Motte Fouqué (1777–1843) was a popular but commonplace writer who lives by virtue of two charming fairy stories, ‘ Undine ’ and ‘ Sintram.’ Immermann wrote ‘ Die Epigonen ’ (1836), foreshadowing the novel of social purpose, and ‘ Münchhausen ’ (1838–9); this last contains an excellent short story of peasant life, ‘ Der Oberhof,’ the first specimen of the peasant literature which was afterwards developed by the Swiss pastor, Albert Blizius, writing as ‘ Jeremias Gotthelf ’ (1797–1854), by Berthold Auerbach (1812–82) and Adelbert Stifter (1805–68), and by Peter Rosegger (1843–1918).

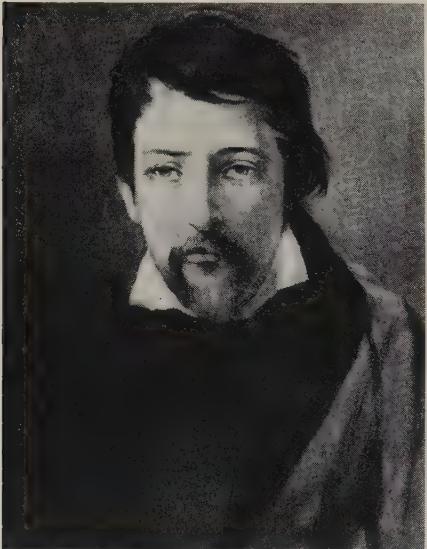
The historical novel had already won popularity, which the ‘ Waverley Novels ’ increased to a furore. Wilhelm Hauff, W. H. Häring (‘ Willibald Alexis ’), Karl Spindler and Heinrich Zschokke wrote in the Scott tradition, which Alexis afterwards outgrew. Later, Gustav Freytag (1816–95) dealt with successive epochs of German history and also wrote novels of social purpose and plays. Georg Ebers and Felix Dahns took their themes from antiquity.

LESSON 14

German III: From Heine to Hitler

The Romantic Movement in Germany did not long survive the death of Goethe in 1832. The 'Young Germany' movement took its place and grew all the stronger under persecution by the Bundestag. The central figure was Heinrich Heine (1797–1856), a Jew of working-class family.

Heine. One of the sweetest singers in all literature, Heine won instant fame with 'Buch der Lieder' (1827), which contains some of his loveliest lyrics; 'Die Lorelei,' 'Die Grenadiere' and 'Du bist wie eine Blume' ('Thou art like a flower') are unsurpassed. Though Romantic at heart, there is in Heine a strain of irony which is alien to the Romantic spirit and in keeping with the new critical trend. He produced several other volumes, of which 'Die Nordsee' is a magnificent cycle of sea poetry, 'Atta Troll' is an enchanting tale with an allegorical meaning, and the 'Romanzero' contains his mature verse, noble and sincere.



HEINE. Lacking appreciation in his own country, Heine settled in Paris in 1831 and married a Frenchwoman. In 1845 he became a victim of creeping paralysis. His Jewish origin militated against his popularity among certain classes.

From a painting; photo, E.N.A.

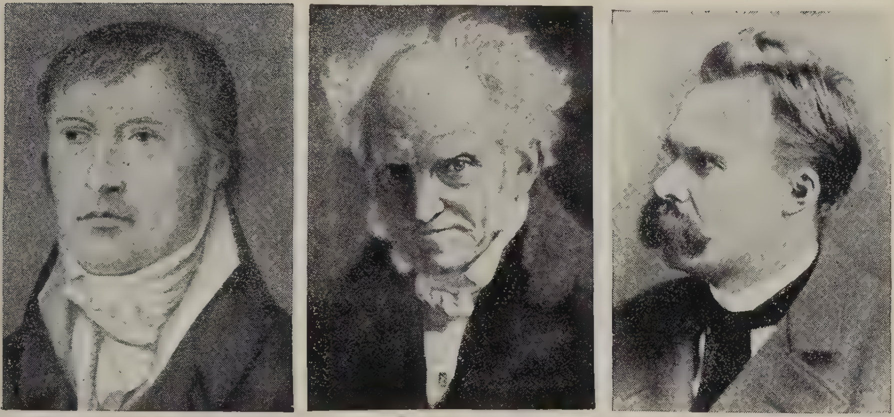
Heine also wrote excellent prose, of which a selection has been translated into English by Hermann Kesten (1943).

Philosophy. Of the German philosophers, Georg Wilhelm Friedrich Hegel (1770–1831) is most important, but wrote obscurely. The deep pessimism of Arthur Schopenhauer (1788–1860) is reflected in Romantic poetry, and his excellent prose style gives added importance to 'Die Welt als Wille und Vorstellung' (1819) and to his essays, 'Parerga und Paralipomena.'

Extremely influential was Friedrich Nietzsche (1844-1900), who laid down the doctrine of individualism, carried to the point where the Superman should be dominant. Nietzsche wrote voluminously and was an artist in prose; his outstanding work, 'Also sprach Zarathustra' (1883–91) is the most important contribution to German literature at this period. (For a fuller discussion of German philosophy see the course on Philosophy in this volume.)

Post-Romantic Novels. Among the chief novelists in the latter part of the century was Gottfried Keller (1819–90), author of 'Der grüne Heinrich,' which was the last great Romantic novel in the tradition of 'Wilhelm Meister': he was also a masterly short-story writer, as were Theodor Storm (1817–88), W. H. Riehl (1823–97), Konrad Ferdinand Meyer (1825–96) and Paul Heyse (1830–1914). Heyse wrote several novels, his 'Kinder der Welt' (1873) being most noteworthy. Karl Gutzkow (1811–78), leader of the 'Young Germany' movement, is best remembered for 'Der Ritter von Geiste' (1850–2), a social novel which attempts to represent a whole epoch; Friedrich Spielhagen (1829–1911) was excellent in this genre. Fritz Reuter (1810–74) was the most important of the provincial writers, using the 'Platdeutsch' dialect of Mecklenburg in his great novels, which have been compared with the work of Dickens. Theodor Fontane (1819–98) was the most influential of the realists.

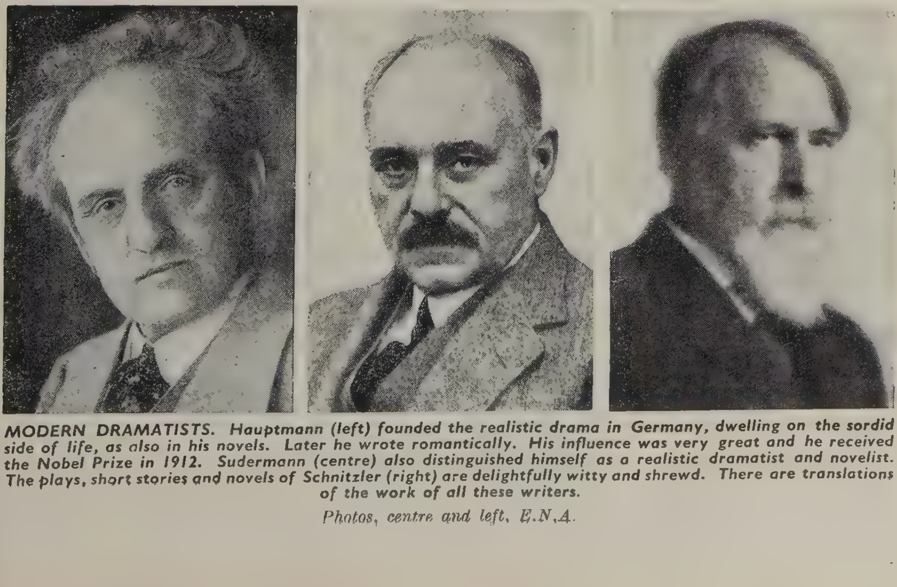
Drama. In drama, Christian Friedrich Hebbel (1813–63) was the first to write plays of psychological interest, forerunners of the work of Ibsen. Otto Ludwig (1813–65) was a realist, who excelled in novel-writing as well as in plays. Ludwig Anzengrüber



THREE FAMOUS PHILOSOPHERS. Hegel (left) ranks among the highest in the world of philosophy. He has been especially influential in England. A great idealist, he held Pantheistic views. Schopenhauer (centre, portrait after Gobel) had studied Oriental thought. His pessimism, like that of the Buddha, does not exclude the existence of the way to salvation. Most dynamic and audacious of thinkers, Nietzsche (right) stressed the importance of the will to power and foresaw the coming of the Supermen.

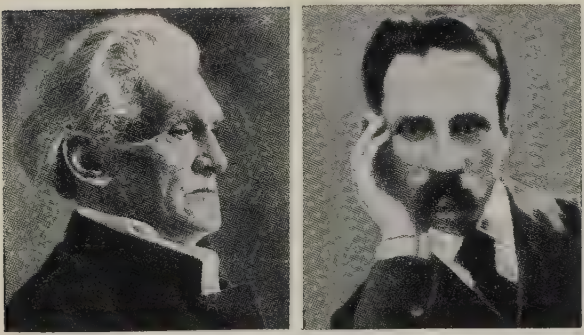
(1839–89) chose his themes from peasant life in Austria.

Gerhart Hauptmann (b. 1862) began his career as dramatist in the late eighties, at first under the influence of Zola and then under that of Ibsen. He wrote a series of plays on pathological subjects, had his first success with the realistic 'Die Weber' (1892), and went on to psychological plays and fantasy, besides comedy. By 1914 Hauptmann dominated the German stage. His only rival was Hermann Sudermann (1857–1928), who had begun a new era of realism with 'Die Ehre' (1889). Sudermann is best known in this country for 'Die hohe Lied' ('Song of Songs,' 1908). These two writers were fine novelists. There were many other talented dramatists, including Frank Wedekind (1864–1918). In Austria drama was worthily represented by the



MODERN DRAMATISTS. Hauptmann (left) founded the realistic drama in Germany, dwelling on the sordid side of life, as also in his novels. Later he wrote romantically. His influence was very great and he received the Nobel Prize in 1912. Sudermann (centre) also distinguished himself as a realistic dramatist and novelist. The plays, short stories and novels of Schnitzler (right) are delightfully witty and shrewd. There are translations of the work of all these writers.

Photos, centre and left, E.N.A.



MODERN POETS. Stefan George (left) is the most generally appreciated and influential of modern German poets. His verse has a classic beauty of style. Rilke, now recognized as the supreme lyric poet of modern Germany, is highly original but obscure. Both poets express a mystic symbolism.

Photo (left), E.N.A.

Viennese Jew, Arthur Schnitzler (1862–1931), famous for his one-act plays and for 'Professor Bernhardi,' and by the half-Jewish Hugo von Hofmannsthal (1874–1929), who wrote lyric drama.

Modern Lyric Poetry. German lyrical poetry in the modern period shows variety and originality. Most important at the turn of the century were Freiherr Detlov von Liliencron (1844–1909) and Richard Dehmel (1863–1920). Liliencron was an innovator in diction; he had a lively impressionistic style. Dehmel, a dynamic figure, was influenced by the French Symbolists, but retained a passionate individuality; he was also an excellent translator of Villon and Verlaine and of Chinese poetry.

Stefan George (1868–1933) produced much work of great beauty and austere power, influenced by Mallarmé; he was also responsible for translations of Shakespeare's sonnets, and of Dante, Baudelaire and the Symbolists. His patriotic verse earned Nazi appreciation.

THOMAS MANN. This world-famous novelist won success with 'Buddenbrooks' (1903) and in 1929 received the Nobel Prize. He left Germany when the Nazis came into power.

The beautiful nebulous writing of Albert Mombert (b. 1872) and Theodor Däubler (1876–1934) and the colourful poems of Max Dauthendey (1867–1918) are impressionistic, in strong contrast with the group of working-class poets, who included Karl Bröger (b. 1886) and Gerrit Engelke (1898–1918).

Rainer Maria Rilke (1875–1926), who was born in Prague, is now recognized as Germany's greatest modern lyric poet, remarkable for subtlety of thought and for originality of form. Of his exquisite poetry the first notable expression is in 'Die Weisse Fürstin' ('The White Princess,' 1899, revised in 1904), an eerie poetic drama in the manner of Maeterlinck. More important achievements are 'Das Stundenbuch' ('The Book of Hours' 1905), a tremendous rhapsodic cycle; 'Neue Gedichte' ('New Poems,' 1907–8), in which scenes and objects encountered on his travels stimulate the poet to re-create the past with which they were associated; the superb 'Fünf Gesänge' ('Five Hymns,' 1914), under the influence of Hölderlin, which marked the outbreak of war; the 'Duineser Elegien' ('Duino Elegies,' 1923), a lurid apocalyptic vision of life, written while he was the guest of Princess Marie Thurn at her Castle of Duino on the Adriatic; and the magical 'Sonette an Orpheus' ('Sonnets to Orpheus,' 1922), metaphysical, even mystical, in content. Rilke also wrote a remarkable Werther-ish novel, 'Malte Laurids Brigge,' which has been described as 'a great symphony of fear'; it reveals the self-torture, the hauntings, the panic, in a morbidly introspective and hyper-sensitive being, identified with the author.

It will be seen that Rilke is not easy to classify. He is essentially individual and might be described as the poet of despair. Pessimism darkens most of his poetry and prose and also appears in his fairly voluminous correspondence. In the years between the World Wars, his vogue in Germany was enormous. His fame will stand, but he has no message of hope and comfort, and it is doubtful whether he will retain popular favour. His obscurity is a deterrent. As Professor Butler, in 'Rainer Maria Rilke,' says:

> Rilke remains baffling, partly . . . because he willed it so . . . Rilke often aimed at misleading his readers, wrapping himself in a cloud of darkness woven from esoteric symbols . . . and we should let him go free had he not spoken so often and so urgently of his message and mission to humanity.

Among the decadents were Georg Heym (1887–1912) and Georg Trahl (1887–1914); and Gottfried Benn (b. 1886), a Berlin surgeon, is starkly realistic.

Impressionism and Expressionism. The impressionistic novel, a development from Zolaesque naturalism, is exemplified in the work of Emil Strauss (b. 1866), Hermann Hesse (b. 1877), Hermann Stehr (b. 1864), Jakob Wassermann (1873–1934), Heinrich Mann (b. 1871) and his brother Thomas Mann (b. 1875). The last named, in his monumental symbolic work, 'Die Zauberberg' ('The Magic Mountain,' 1924), used psycho-analysis to indicate the moral degradation of the period just before the First World War in Germany.

A quite modern phase of literary art is expressionism; instead of relying upon 'impressions from without' for his stimuli, the artist finds expression from the inward self; his intensity of realization often results in impressionistic imagery. In accordance with Freudian doctrine, there is no attempt to suppress the unsavoury or trivial.

The leading expressionists in fiction were Rene Schikele (b. 1883), Franz Kafka (1883–1924), Leonhard Frank (b. 1884), Kasimir Edschmidt (b. 1890), Alfred Döblin (b. 1878) and Franz Werfel (b. 1890), world-famous for 'The Song of Bernadette.' Döblin's 'Berlin Alexanderplatz,' and the 'Perrudja' of Hanns Henny Jahnn (b. 1894), are the first German novels in the manner of Joyce's 'Ulysses,' both appearing in 1929. Werfel is also a poet and dramatist, author of the symbolic trilogy, 'Der Spiegelmanch.'

EXPRESSIONISTS. Toller (left) wrote plays and poetry in revolutionary spirit and style. His influence was especially marked in Russia. He became a political refugee in 1933. Kafka (right) was one of the earliest writers of expressionist novels.

Portrait of Toller by L. Jacobs; photos, E.N.A.

Vicki Baum (b. 1888), published 'Menschen im Hotel' ('Grand Hotel,' 1929) and other novels in the expressionist manner.

Expressionistic drama found its chief exponents in Georg Kaiser (b. 1878) and Ernst Toller (1893–1939), who were Communists. Kaiser's best known plays are 'Die Bürger von Calais' (1914), 'Von Morgens bis Mitternachs' ('From Morn to Midnight,' 1916), and 'Gas' (1918–20). The works of Toller, a political refugee from 1933, have been widely translated. His best known plays are 'Masse-Mensch' ('Masses and Men,' 1921) and 'Die Maschinenstürmer' ('The Machine Wreckers,' 1922). Violence and abnormality give a distorted effect to the work of such expressionists as Arnolt Bronnen (b. 1895) and Oskar Kokoschka (b. 1886).

Other Aspects. The historical novel has continued to be important, in its modern form. Guido Kolbenheyer (b. 1878), a mystic, is at his best in a trilogy on Paracelsus. Ricarda Huch (b. 1864) is without doubt Germany's foremost woman writer. She brought to historical

TWO WOMEN NOVELISTS. Ricarda Huch (left) is the outstanding woman writer in Germany, excelling in historical studies. The novels of Vicki Baum (right) are very popular; she emigrated to America in 1933.

Photos, E.N.A. and Hoppé

fiction a breadth of vision, a psychological insight and a lyric style which turn her studies of Italian history and of the Thirty Years' War into prose epics. She also wrote excellent social novels, short stories and lyrics. Stefan Zweig (1881–1943) wrote the cinematographic 'Marie Antoinette' (1932), which made a successful film; he is a lively biographer. Alfred Neumann (b. 1895) wrote the exciting 'Der Teufel' (1926) and 'Königin Christina von Schweden.' 'Jud Süss' ('Jew Suss') by Lion Feuchtwanger (b. 1884) became a best-seller. Emil Ludwig (b. 1881) wrote successful novels and plays, but after his 'Goethe' (1920) he devoted himself mainly to biography.

The First World War produced another world-famous novel, 'Im Westen Nichts Neues' ('All Quiet on the Western Front,' 1929), and its bitter sequel, 'Der Weg zuruck' ('The Way Back'), by Erich Maria Remarque. A more lasting reputation was won by 'Der Streit um den Sergeanten Grischa' (1926–7), by Arnold Zweig (b. 1887).

English readers are also familiar with the delightful child-stories of Erich Kästner (b. 1899), author of 'Emil und die Detektive,' and with Hans Fallada's (b. 1893) poignant 'Little Man, what now?'

Of the thinkers, Oswald Spengler (1880–1936) propounded the decay of Western civilization and the coming of dictatorships in his famous 'Der Untergang des Abendlands' ('The Decline of the West'), much of which he afterwards recanted.

'Mein Kampf.' The year 1924 saw the appearance of that strange, epoch-making book, 'Mein Kampf,' written by the Austrian Adolf Hitler (b. 1889). To a Germany that was still in despair after military defeat, and struggling to find a new soul, Hitler promised recovery and power through 'National Socialism.' Never in history has so incoherent and ill-written a work produced such effects. It touched the predatory and war-like instincts of the nation, and reanimated its desire for revenge and domination. It was supplemented by Alfred Rosenberg (b. 1893), who in 'The Myth of the 20th Century' provided the elaborated reasoning that was lacking in Hitler's elemental and elementary work.

These books laid it down that Germany had been betrayed at home in 1918, mainly by Jews, and never defeated on the field of battle; that the Jews were responsible for most of Germany's ills; that the Treaty of Versailles was an unjust swindle on a great people; that everybody but the German was 'decadent'; and that the 'pure, Nordic' Germans were 'Herrenvolk,' a 'Master Race' destined to rule the whole world. Fantastic as these ideas may seem, they were swallowed eagerly, and especially by the younger generation. In 1933 Hitler and his supporters achieved political power. With it, they changed the face of Germany.

Nazi Control. The Nazis immediately began a liquidation of all writing which did not suit their fanatical, aggressive creed. The burning of the books began. It is thus described in an official publication:

> The fire of the pyres which flared up in German lands in May, 1933, is to us a sign and a symbol of an inflexible will to purity.

The Prussian Academy of Arts was purged of men of liberal, humanitarian or democratic tendencies and, of course, of all Jews. It was renamed the German Academy of Literature, and Stefan George was asked, but refused, to become President in place of Heinrich Mann, who had left Germany. A decree of September 22, 1933, set up a very strict control of all the arts under Dr. Goebbels (who had himself failed as a writer). A list of forbidden books and authors was issued; it included Heinrich Heine, since he was a Jew. It is interesting to compare this with what had happened in the U.S.S.R. after the Russian Revolution (*see* page 352). In Russia literature recovered and began to flourish; in Germany it all but died.

Of the established writers, Stefan George remained somewhat apart from the New Order; Gerhart Hauptmann, Ernst Wiechert, Ernst Junger, Ernst Bertram, Rudolf G. Binding, Ina Seidel and Agnes Miegel continued to find favour, and Erwin Guido Holbenheyer became highly popular.

'Blubo.' The younger generation produced work of the true Nazi tone and ideology. One of their theorists, Walther Darrë, took the motto 'Blut und Boden' ('Blood and Soil'), and from it sprang the 'Blubo' school of writers, who emphasized the importance of (German) blood and (German) soil. Friedrich Griese (b. 1890) and Ernst Wiechert (b. 1887) are leading exponents of the 'Blubo' novel.

Expansionist dream-fantasies of Nordic supremacy and world power entered into novels, short stories, verse and plays. Histories were rewritten to accord with the new credo.

It is to the emigré writers' works that one must look for the best that was produced between 1933 and the end of the Second World War. This includes the 'Behemoth' of Franz Neumann, a profound study of the new Germany and the Nazi creed.

LESSON 15

Russian I: Early Times to the Great Age

While it is true that there is an old Russian literature dating back a thousand years, it must be admitted that most of it is of interest to students of history and civilization rather than to those of literature as such. But the old literature of the 10th to the 15th centuries holds the essential material on which to base estimates of Russian character and psychology, with their various conflicting elements—Mongol, Tartar, Germanic and Slav, to mention but a few—all of which is of inestimable value in understanding the literature of later and greater ages. One realizes from those old works that the characteristics which we designate as 'Russian' can be traced back first to the clash, then to the mingling, and finally to the blending and harmonizing of various races and psychologies.

The history of a succession of turbulent periods is recorded for the most part in a somewhat casual and desultory way, though often with insight and penetration. The clash and mingling of races struggling among themselves developed into a vast conflict with a combination of conditions hostile to human existence: the severity and extremes of climate together with the almost constant perils of foreign invasion being the most noteworthy. We can deduce from the records of the old literature a gradual process of blending of the many seemingly contradictory elements which make up Russian character: ruggedness, strength, cruelty and tenacity with elasticity, good-nature, kindliness and extreme sensitivity. It is in that same period that we find the roots of the Russian's almost unequalled ability to suffer, and discover from it that this knowledge of suffering, ingrained in the race, has given the ability not only to practise but to express compassion.

There are few masterpieces in old Russian literature, but those we know of place these early factors of race and character under a microscope. One work deserving mention is 'The Campaign of Igor' (*c.* 1186). It stands almost alone in that it is native, secular (as contrasted with a mass of ecclesiastical) poetry in narrative form. Not only is this a considerable work of literary art, but it is a source book for contemporary customs, problems and outlook. Between the famous 'Igor' and the remarkable 'Autobiography' of the Archpriest Avvakum (1620–81) there is no very definite line of development, no outstanding works, no strong evolution of a literary tradition such as one finds in Italy, France, Spain or England in the same period. Yet there were very definite developments and progress in the two most important elements which go to the making of a literature.

Two Formative Elements. First, the Russian language developed continuously and progressively; this still goes on in our own times. A very wonderful literary instrument that language is: rich, highly flexible and subtle, it is capable of tremendous energy and power, great elegance and sonority, while its range covers the whole circle of melody, delicacy, refinement and the picturesque. Its extraordinary ability to embody in one word a set of ideas or a whole figure, together with a wonderful variability of the tonic accent, render it capable of almost every imaginable rhythmic combination, and make it the ideal language for the poet and for what is more common with the Russians than with us, the writer of poetic prose.

The second important element, due to the harsh general conditions of life, was the development of an intensely realistic outlook, with which went the elimination of any tendency to abstraction and the metaphysical or sentimental spirit. The complete absence of sentimentalism in Russian literature often strikes the English reader as a little too brutally positive. In some writers, the realism goes so far as to bring scepticism and irony to the point of melancholy, and even to that curious and essentially Russian mysticism which Dostoevski was to show to a remarkable degree in a later age. These two elements—the language and the realistic outlook—both traceable from the earliest times, make Russian literature what it is.

We find, strangely enough, that Russian writers of poetry, prose and the drama, do not show great originality in the evolution of new forms, though there are exceptions. The originality of the Russians lies not in the creation of new forms but in an intense application of individual genius combined with creative forces outside the field of literature. The Russians were content to accept well-tried forms from outside sources: especially from the Italian Renaissance and from the French, but also from the Germans and even the Poles. A sort of pedigree of foreign literary forms began to naturalize itself in Russia from the 17th century onwards, and remains to this day deeply rooted in the national culture.

The Classic Period. Literary historians find it convenient to date modern Russian literature from about the 17th century and, because of his genius, to regard the works of Mikhail Vasilievich Lomonosov (1711–65) as the crystallization of this tendency. Lomonosov based his art on classical French literature. Such was his influence that he has been called the Peter the Great of Russian literature. This fisherman's son, who became a critic, a professor and a savant, was in his own time likened to Pindar, Cicero, Virgil and Malherbe. If today his actual writings are less highly esteemed, it is fully recognized that his influence wrought great progress in others, and that it counted for much in the formation of the whole cultural outlook of such fine teachers as Karamzin (1765–1826) and Zhukovski (1783–1852), whose essays, articles and translations familiarized the Russian public with the most important works of many famous European authors. This period also produced the great fabulist Ivan Andreievich Krylov (1768-1844) who began by translating La Fontaine but went on to original work full of the salty humour of the Russian peasant.

Pushkin. We now come to the supreme name in Russian literature. Alexander Sergievich Pushkin (1799–1837) sprang from an old, noble family. There is a curious feature in his ancestry: his maternal grandfather was a full-blooded African negro named Hannibal who was a favourite of Peter the Great. Pushkin's father was a highly cultured man of wide knowledge, cosmopolitan tastes and a Voltairean outlook. He possessed a fine library, in which little Alexander found delight from childhood. His house in Moscow was open to all men of culture, and to it came the outstanding writers of the age. From the books in the library and from listening to the conversation of the greatest literary figures of the age, young Pushkin began to develop a love of literature and to imbibe the knowledge and wisdom which were to leaven all his works.

PUSHKIN. The supreme Russian poet, Pushkin was dismissed from the Civil Service for his revolutionary views. He was killed in a duel.
Portrait by W. Tropinin

It is recorded that his excessive idleness at school and college were the despair of his teachers. They reported painfully that he had 'little of a future before him.' But Pushkin was not idle. He had already begun to contribute to various periodicals, either anonymously or under initials, critical essays and verse; and at the age of nineteen astonished his friends with the reading of his faery romance, 'Russlan and Liudmila.'

From then until his death, Pushkin was a most prolific writer of prose and poetry. Notable prose works are the novel 'The Captain's Daughter' and short stories such as 'The Queen of Spades.' It is, however, on his work as a poet that his unchallenged reputation is based. No translation can do him justice; he must be read in the original to be appreciated; his mastery of the imponderables of the language is unequalled. Prince Mirsky says:

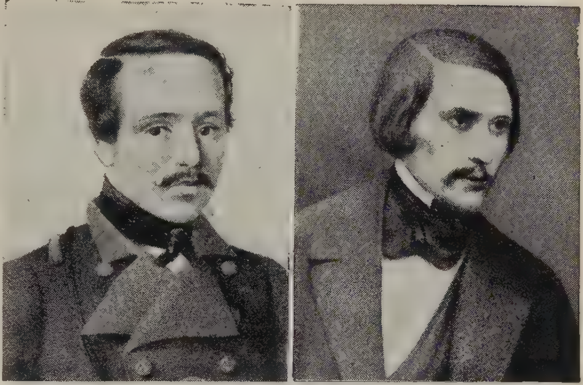
> It is difficult for the foreigner, perhaps impossible if he is unacquainted with the language, to believe in the supreme greatness of Pushkin among Russian writers. Yet it is necessary for him to accept the belief, even if he disagrees with it.

His greatest work is 'Evgeni Onegin,' a novel in verse in the Byronic manner, dealing with contemporary Russian life. This has never been surpassed. It was the first important Russian novel, forerunner of the splendid Russian novels of the 19th century. Of equal importance was the noble tragedy, 'Boris Godounov.'

Pushkin's reputation today stands higher than ever; and shows no signs that it is ever likely to decline. As a master of language and style, he is supreme. While intensely Russian in outlook and dealing with Russia and Russians in all his works, he is a universal writer—unequalled, as Dostoevski says, for his 'pan-humanity.' His books abound in superb characterization, in humour and tragedy of equal power, in descriptions of real beauty.

The publication of Pushkin's first book in 1820 was the beginning of what has been called the 'Golden Age of Russian Poetry,' which ended in 1831. His tradition was carried on by Mikhail Yurevich Lermontov (1814–41), who in his short life wrote lyric and dramatic poetry, much of it being inspired by the legendary beauty of the Caucasus. 'The Demon' has been translated into English, as has his famous novel 'The Hero of Our Times.'

Gogol. Of this period, too, is Nikolai Vasilievich Gogol (1809–52), whose satirical epic 'Dead Souls,' written in a prose that is ornate and elaborate, was to be the foundation of the realistic novel in Russia. It is a humorous, picaresque novel and at the same time a social satire with political implications, for it holds up to ridicule the abuses of serfdom. The tsarist censors forbade views, opinions and criticisms of established institutions such as serfdom, and writers took on many cloaks to cover their efforts to expose and condemn the vice, corruption and exploitation that were the common practices of rulers and officialdom.



FAMOUS WRITERS. *Lermontov (left), an officer in the Guards, wrote a revolutionary ode on Pushkin's death and was exiled to the Caucasus, which gave him the scenery for his romantic poems. Gogol (right), a minor clerk, was befriended by Pushkin. 'Dead Souls' made him famous, but religious mania developed and checked his output.*

In 'Dead Souls,' while ostensibly chronicling the adventures of a rascal and vagabond, Gogol gives us a very realistic survey of actual conditions among the serfs, in which there is behind the façade of the comic and hearty a deep sadness and pity. Hence, it is not only as a great storyteller that he has ever since been esteemed throughout Russia but, since the Revolution, as one of the noble band of writers whose social conscience prompted them to strike a blow on behalf of the downtrodden and illiterates who were helpless to aid themselves. Gogol is also famous for plays, the most popular being 'Revisor' (i.e. Inspector, published in English as 'The Government Inspector'); and for 'Taras Bulba,' an epic tale of the Cossacks. He wrote many other works that are too essentially Russian to be translated.

Pushkin in poetry, Lermontov and Gogol in prose—these are the names which stand out on the threshold of the Great Age of Russian literature, in which almost the whole of the 19th century may be called golden. This Great Age is dealt with in the next Lesson, but in reading of it one must bear in mind our introductory remarks on Russian character and outlook as recorded in the very early works. As the literature developed and, in the novel, reached its highest point, all of it continued to show those fundamental racial and traditional characteristics that are immediately recognizable as Russian.

LESSON 16

Russian II: The Great Age

FROM the publication of Pushkin's first work in 1820, to the Revolution of 1917—roughly one hundred years—is considered to be the Great Age of Russian Literature. It was an age in which the novel dominated both poetry and drama—excepting always Pushkin's work. What a constellation of great writers came on the scene during it! One must select only the outstanding ones; and then fail to do them justice.

Nikolai Alexeivich Nekrasov (1821–77) was the most important Radical, or as we should say, 'Left Wing,' writer and editor of the middle period of the century. Adored by the people and the revolutionary intelligentsia, he was detested by the aristocracy and officialdom. His review 'Sovremennik' ('The Contemporary'), although mainly radical, attracted all the best writers. It was in it that he first began to publish his own verse; and on it his fame rests. Nekrasov's influence on political thought is not forgotten today in the U.S.S.R., but that alone would not have won for him the sure place he has in the national literature. He holds this place because of two factors: his unquestioned ability as a poet and the deep expression of his love of the common people. The latter dominates everything he wrote. His poetry is vigorous, realistic, with astonishing verbal felicity; there is no prettiness in it or any sign of catering for the conventions; at times it is profound; and at times it descends into cheap rhetoric and vulgarity. Yet he was a powerful satirist and master of invective who could at times introduce into his work a strange, haunting lyricism. He wrote all kinds of verse, including love poetry and works for children, the latter being more highly esteemed than the former.

Of all his work, it is largely due to 'The Pedlars' and 'Who can be happy and free in Russia?' that Nekrasov stands head and shoulders above his contemporaries. It is on these two poems, the first a rollicking, lively folk-ballad, the latter a vast, realistic and satirical epic dealing with peasants' wanderings in search of a happy Russia, that his reputation will rest for all time. Both are still immensely popular; they still run to edition after edition. It may seem strange that so vital and popular a poet should not have found imitators, but it appears as if nobody has been able to follow in his footsteps. He remains the giant of the satirical epic. There is a good translation of 'Who Can be Happy . . .' and also of another fine poem, 'The Red-Nosed Frost.'

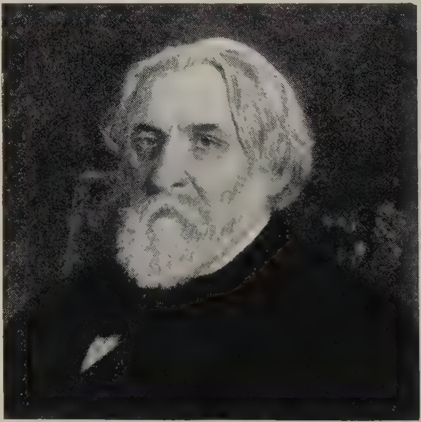
NEKRASOV. *Though a landowner's son, Nekrasov had no support from his family. His great epic describes the travels of seven peasants seeking enlightenment.*

From the portrait by E. N. Kramskoy

Alexander Nicolaevich Ostrovski (1823–86) is the outstanding dramatist of his period. He wrote for 'character actors' rather than created characters, for he presents types rather than analyses them. Few dramatists excel him in his own field. His plays, like most Russian plays, are undramatic by our standards and do not pay much attention to plot, though admirably constructed for acting. What makes them of permanent interest is their close attention to the manners and idiosyncrasies of types we all know too well: the unscrupulous merchant, the crooked lawyer, the domestic tyrant, the selfish old woman, the money-grubbing commercialist, and so on. Such types he drew perfectly.

So great was his popularity that for at least thirty years he dominated the Russian stage, and around his works grew a school of actors of which there are still followers today—the Russians like the Ostrovski 'type'-play which gives scope to the character actor, and in our own time plays following the Ostrovski tradition continue to appear. Ostrovski's types are lively, vigorous, vulgar people. He deals with them objectively—some of them we hate, some we pity, others we can almost esteem. His greatest work—and it is one of the masterpieces of Russian literature—is 'The Thunderstorm.' This is a piece of dramatic poetry which alone would place him among the immortals. It was translated by Constance Garnett in 1899.

Turgenev. While Nekrasov and Ostrovski exemplify the best in poetry and drama, it is to the prose writers that we turn for the really great literature of the 19th century. Ivan Sergievich Turgenev (1818–83) had the



TURGENEV. *Member of an impoverished noble family, Turgenev's liberal political views led him to pass most of his life in a self-imposed exile, first in Baden and later in Paris.*

From the painting by J. E. Répine

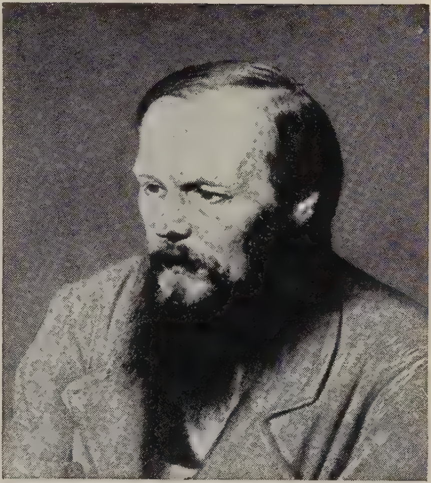
good fortune when a student to make the acquaintance of a Professor Pletnev who was an intimate friend and worshipper of the great Pushkin, and from Pletnev he imbibed an enthusiasm to follow the classical tradition. Like Pushkin, he began as a poet but, in spite of the appreciation of the critics, abandoned poetry for prose and would never allow his early efforts to be republished.

In 1846 appeared his 'Sportsman's Sketches,' as a serial which attracted little attention; when it came out in book form it brought him immediate fame. There could be no doubt in any reader's mind but that here was a great writer. One of the sketches called 'The Bezhin Meadow' is a prose-poem so perfect in style and form that it is an established masterpiece of the language.

When Gogol died, Turgenev wrote a glowing appreciation in terms which displeased the authorities and cost him a month in prison and eighteen months' banishment. After it sketches, short stories, essays and novels flowed quickly from his pen. The most famous are: 'A House of Gentlefolk' (1858); 'On the Eve' (1860); 'Fathers and Sons' (1862) which excited controversy; and, after he had left Russia and made his home in Baden, 'Smoke' (1867) and 'Virgin Soil' (1877). His short stories include 'Aysa,' 'First Love,' 'A Lear of the Steppes' and 'Torrents of Spring.' He wrote an excellent play, 'A Month in the Country,' which has achieved popularity in England. Turgenev has a pure, straightforward style and his work is appreciable in translation.

He was regarded at home as Russia's foremost writer; his fame began to extend over Europe. Abroad, his works were translated and discussed, and he has the distinction of being the first Russian author to have lived to see his works published in the principal European languages. Today in Russia his works are as popular as ever.

Dostoevski. We come now to Feodor Mikhailovich Dostoevski (1821–81), that strange, uncanny genius whose chief works belong to all literature and to all time. Unlike his predecessor Turgenev and his contemporary Tolstoi, Dostoevski, though not a plebeian, had financial difficulties. At the university he took a brilliant degree in engineering. He entered the army with a commission, but left it after three years to devote his life to literature. His faith was a humanitarian socialism and, when his first novel 'Poor Folk' appeared in 1845, Belinski and Nekrasov acclaimed it and announced that a 'new Gogol' had arrived.



DOSTOEVSKI. Profoundly sympathetic with the oppressed poor, Dostoevski himself endured poverty and spent four years in a Siberian prison because of his views. He lived for many years at Baden.

From the painting by V. G. Perov (photo, E.N.A.)

His next book 'The Double' completely baffled and bewildered the critics, some of whom received it with derision. It deals with borderline insanity and reached a profundity of subtle analysis and psychological insight hitherto unknown. The author was so hurt by the reception given to his work that he quarrelled with his literary friends and withdrew into himself, but continued to write with redoubled energy.

Suddenly this highly sensitive man of genius had an unimaginable experience. His extreme revolutionary views caused his arrest and trial and resulted in a sentence of death. With some others he was led to a square, half-stripped, in mid-winter, to be executed—a scaffold and hangman ready, a cart with coffins near by. He could not understand it at all. 'Is it possible that we are going to be executed?' he asked of a fellow-prisoner. At the very last moment they were reprieved. One of them lost his reason completely. Dostoevski, an epileptic, was sent to Siberia for four years' imprisonment, after which came three years' army service.

There is something tremendous in the Russian's ability to suffer, for this terrible ordeal had an effect the reverse of what might be expected. Dostoevski returned stronger morally and more balanced in mind than ever before. 'Memoirs of the House of Death,' a work of extreme realism, was the first fruit of his imprisonment, to be followed by an intensively creative period in which novel quickly succeeded novel—'Crime and Punishment,' 'The Idiot' and 'The Possessed,' to mention only three, each of which is a masterpiece—until in 1880, the year before he died, was published 'The Brothers Karamazov.'

Where Dostoevski differs from every other novelist is in his approach to the main problems of life, based upon his analysis of the spirit which, to him, is *not* always identifiable by men's acts. He sees man as a being composed of two opposing qualities which, for convenience, we may call good and evil. The line dividing these two is in the mind, in the spirit, if you will. It is this strange frontier which Dostoevski explores as no other writer has ever explored it. Into a story of human adventures and passions he weaves an analysis of the minds of his characters which is much more than the analysis we find in other writers. He explores, analyzes and charts the results for us in such a way that we can see them clearly and in a way that we never before suspected. This is the oustanding quality of Dostoevski.

One may cite an example of his method from 'The Brothers Karamazov.' In this novel he tackles the problem of our dual nature. Within us are the two powers of good and evil, and it often requires the shock of some great experience to bring out the one or the other. The saint may be a potential murderer; the murderer a potential saint. It is possible for a man to commit a crime and not be a criminal, because some event or circumstance has brought out an otherwise latent potentiality. If the will and desire to commit crime are not normally existing in a man's mind, one act committed in the stress of extraordinary and abnormal circumstances hardly makes him a villain.

In 'The Brothers Karamazov,' the man Smerdyakov killed Ivan's father and was held to be a murderer because of this physical act. But Ivan, by a process of suggestion, willed and encouraged Smerdyakov to commit the murder, and hoped thereby to escape responsibility. In the mind of Ivan there was the will and desire to see this murder committed; in Smerdyakov it did not exist until it was evoked by the other man. The real criminal is Ivan, who, knowing it, falls a victim to his conscience and gradually lapses into madness. This is a characteristic Dostoevski theme, and it is in his handling of the subtleties of such themes that he excels all other writers. In 'Crime and Punishment' he takes as his theme the dangers of unlimited freedom of the will—his main character Raskolnikov attains such a height of mental and spiritual freedom that he thinks he can do no wrong.

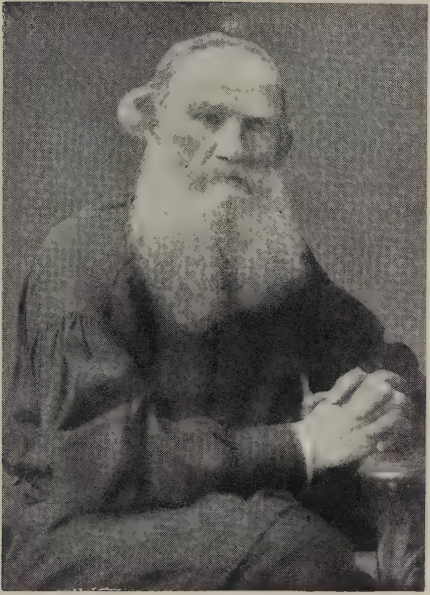
In this book and in 'The Idiot'—one may say in all his books—Dostoevski is intensely preoccupied with the Russian soul. He emphasized again and again that the strength of Russia lies in her faith in man and the rejection of superstitions which would impair that faith. One need not seek further for reasons why the Russians appreciate his works.

Apart from this, Dostoevski's place in world literature is secure. As a background to all his work there is a humanitarian, socialistic philosophy to which is added a microscopic knowledge of human nature and mental processes drawn chiefly from his own experiences and his close observation of his fellow-men. All his writing is creative in the fullest sense—creative of dynamic ideas which he struck off as he analyzed the human mind and soul on the hard anvil of life. In this he has no equal. So long as there is literature, his works will be read.

Tolstoi. One towering genius such as Dostoevski would suffice for an age, yet contemporary with him was Count Leo Nikolaevich Tolstoi (1828–1910), a landed aristocrat who became a man of letters and social reformer, of literary rank equal to Dostoevski's. From the time when first he began to write, Tolstoi showed a remarkable faculty for imparting to all his work the illusion of absolute truth. Perhaps 'illusion' is the wrong word, for in all of it one finds a fidelity which causes the reader to say '*This* is not fiction; it is *life*!'

Because of his economic independence—he always refused to make money from his writings—Tolstoi felt himself to be a man with a mission to humanity, one with an absolute duty to teach the good and to expose the bad. His output was considerable—essays, criticism, philosophy, religion, tales, sketches, educational works, drama, and, of course, his fine novels. Much of it is now in oblivion, but the whole world reads with undiminishing admiration his two novels 'Anna Karenina' and 'War and Peace,' each a masterpiece.

Some of the best critics assert, not without justification, that 'War and Peace' is the greatest novel ever written. It is certainly the greatest historical novel—there is nothing in any literature quite like it and, from its first appearance (about 1866) to this day, its defects (which include a loose, wandering and even disconcerting construction) have not shaken its widespread popularity nor



TOLSTOI. Following a spiritual crisis, Tolstoi evolved his own religion and practised simplicity of life. He worked and dressed like a peasant, adopted a vegetarian diet and would have renounced his wealth if his wife had not prevented him.

the opinions of critics of all nations. Tolstoi's characters have the actuality of real flesh and blood, with passions, virtues and failings that he records with unequalled verisimilitude. These two books are 'slices of life' in the truest sense. No writer is a more exact observer; none can use words better to convey truth; and none is more of a fanatic for the truth. It is this quality which makes Tolstoi a giant. To the Russians, his name is one of the greatest.

The two qualities which make 'War and Peace' and 'Anna Karenina' real master novels, especially the former, are the author's ability to convey the idea of spaciousness and his complete mastery of his vast material. Tolstoi declared that truth is his only hero. His work shows something besides: that the ordinary people are also his hero. He shows the wisdom of ordinary people, and there is in both of these novels an implied philosophy that we should be led by, rather than lead, the mass, for man is powerful only when he is borne on waves of that great ocean. In 'War and Peace' he shows that Napoleon flattered himself that he was leading Europe, whereas he was simply the floating toy on a mighty historical current. In 'Anna Karenina' he shows that the simple-hearted but essentially good Levin finds truth and a solution of the problems of life, whereas the intelligent Vronski, who is devoid of this straightforward outlook, merely brings disaster on himself.

This is the philosophy behind Tolstoi's work, and so powerfully does he present it that we have only one word to describe it: great. Tolstoi in the 19th century was the prophet of the 'century of the common man' which idealistic politicians began to propound during the Second Great War. If time and circumstance should prove him to be right, his place in literature will be higher than ever. If his diagnosis should continue to be premature, it is still impossible to deny its greatness.

One should mention that the last half of the 19th century produced in Russia many writers who were the philosophic fathers of the Revolution. While their works may be important politically, only one deserves to be included in a survey of literature, and that is Prince Peter Alexeivich Kropotkin (1842–1921), a man of science and letters and the leader of a school of Anarchist thought of which he is the philosopher (*see* Social History, Vol. III, p. 98).

Earlier writers who must not be forgotten are Mikhail Ievgravovich Saltikov (1826–89), a social satirist of pungent skill, and Sergei Timofeevich Aksakov (1791–1859), author of the 'Family Chronicle,' a work of much social importance written in perfect prose.

Ivan Alexandrovich Goncharov (1812–91) in his novel 'Oblomov,' depicting an indolent, contemplative country squire, gave the word 'Oblomovism' to the Russian language. Nikolai Semovich Leskov (1831–95) was the author of 'Soboryane' ('Cathedral Folk') and many short stories; one of these, 'Lady Macbeth of Mtensk,' is the subject of an opera by the modern composer Dmitri Shostakovich. These are but a few of the names firmly inscribed on the remarkable roll of the century.

Chekhov. Finally, there is Anton Pavlovich Chekhov (1860–1904), whose play 'The Cherry Orchard' is known throughout the world, and whose other plays 'Uncle Vanya,' 'The Three Sisters' and 'The Seagull' have an assured place in the suggestive, poetic drama which deals with the permanent clash between men of dreams and men of action. Chekhov also wrote short stories of great merit, and in his own day it was the stories which first brought him fame, though now it is on his plays that his reputation chiefly rests. In the plays, he avoided the intentional vagueness which characterizes his tales. His drama, though psychological and suggestive, is never hesitant, and what in a less skilful dramatist would fail to convince by its seeming dreaminess, in Chekhov's plays holds the audience by the intensity of the interest.

Abroad, much of his reputation has been won for reasons that are entirely wrong. He is too often regarded as the dramatist of extremely 'Russian' characteristics, because of the strange assembly of neurotics and half-crazy creatures who flit across his stage. These characteristics, as we now well appreciate, are not typically Russian. They are common to all hot-house societies, as they were to the rich and spoiled Russian aristocracy and land-owning classes who did nothing but 'enjoy' life. The tradition established in this grand age of Russian literature was continued by two notable realistic writers, Ivan Bunin (b. 1870) and Alexander Kuprin (1870–1938). Bunin's fame rests on 'The Village,' 'Sukhodol' and 'The Gentleman from San Francisco.' Several of Kuprin's novels have been translated into English; best known are 'The Duel,' The Bracelet of Garnets,' 'The Swamp' and 'Yama' ('The Pit'). He is a master of the short story. Dmitri Merezhkovski (1866–1941) was the author of many esoteric volumes. 'The Forerunner,' a story of da Vinci, has been widely read in English.

CHEKHOV. The work of Chekhov is of intense psychological interest, its theme being generally the conflict between the sensitive mind and the actualities of life.

Following the sensation caused by Gorki (*see* p. 353), Leonid Andreyev (1871–1919) came into vogue, first as novelist, then as playwright. In poetry, the symbolists Alexander Blok (1880–1921), author of 'The Twelve,' and Andrey Bely (1880–1934) had tremendous influence.

LESSON 17

Russian III: Soviet Literature

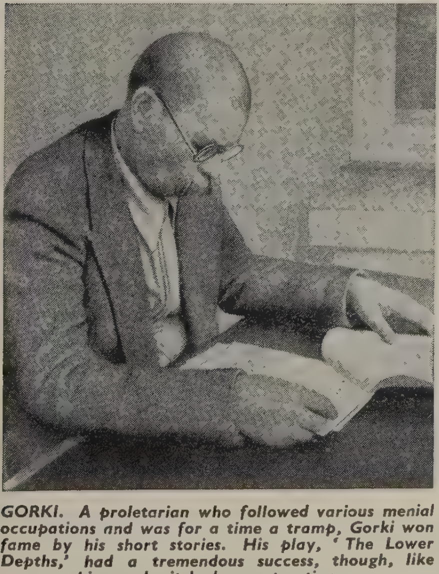
The Revolution of 1917, which had long been fermenting, and of which the politico-philosophical background was the thought of Marx and Engels set out in terms of dialectic and practice by the genius of Vladimir Ilyich Ulianov (1870–1924)—better known as Lenin—was an event which marked the end of an epoch and the beginning of a New Age in what became the Union of Soviet Socialist Republics. It caused sharp lines of division among writers. One group, which included some popular but no great authors, fled abroad and gradually died out while still emitting venom against the new régime. A comparatively small group of authors, including Gorki and Mayakovski, openly joined the Revolution. The majority of writers became known as 'fellow-travellers' with the Revolution: that is, not only did they not oppose it, but they gave it their sympathy and moral support, though not politically-minded. Most of them eventually fell into line with revolutionary thought.

Literature tended to become propaganda, and it is a broad fact of literary history in general that, whenever literature changes to propaganda, art is sacrificed. Very few works of literary importance were produced during those first years of turmoil, war, famine and social precipitation, and what did appear was the work of writers already established—Gorki and Mayakovski, for example. But the traditions were never abandoned. Writers still followed the 19th century Realists, Symbolists and Romantics. They kept to the old forms. It was only the thought which changed—thought reflecting the new background of the Revolution, new political ideals, a new social evolution.

Those pre-Revolution authors who accepted the Revolution are of real historical importance, for they became the carriers of culture and literature from the Great Age to the New Age. They carried over the old tradition; and adapted it to the new circumstances. Among the most noteworthy is Alexei N. Tolstoi (b. 1882), once Count. His trilogy, 'The Road to Calvary,' portrays Soviet achievement and, with Sholokhov's work (page 354), reaches the apex in fiction. It received the Stalin Award in 1943, as did Tolstoi's vigorous 'Peter I' in 1942. Another writer who has devoted his talents to the new order is Ilya Ehrenburg (b. 1891), a prolific and effective journalist. His writings give the impression of haste, and thereby lose in solid worth. His novels 'In a Moscow Street' (1927) and 'The Fall of Paris' (1942), probably represent his best work—they are admirable combinations of vigorous reportage and fluent story-telling. During the Second Great War Ehrenburg's propaganda work was a vital asset.

Other important writers from pre-Soviet days are Alexei Remizov (b. 1877), Mikhail Prishvin (b. 1873), and Evgeni Zamyatin (b. 1884). All these were 'fellow-travellers' who supported the Soviets; though Zamyatin wrote a novel called 'We' which the State considered to be politically unsuitable for publication in the Soviet Union, they allowed it to appear abroad.

Gorki. Head and shoulders above all these was Alexei Maksimovich Peshkov (1868–1936), known to the world as Maxim Gorki (the pen name means bitter, and that word describes much of his work). Gorki wrote novels, plays, short stories, essays and articles. He was famous long before the Revolution. A friend of Lenin and of the Revolution, which he had foreshadowed, during the period of storm and violence he used his influence to prevent the persecution of authors who had not his foresight. In this he rendered invaluable services to literature, for the author who did not immediately and fully accept the new order was suspect. The wisdom of Lenin, supported by the expert counsel of Gorki, prevented a great hiatus in Russian literature, for in such circumstances as those then prevailing in Russia authors tend to cease from writing altogether. Gorki encouraged them to produce and create. Lenin saw that, even though all that they wrote was not entirely to his liking, they were allowed to continue.



GORKI. A proletarian who followed various menial occupations and was for a time a tramp, Gorki won fame by his short stories. His play, 'The Lower Depths,' had a tremendous success, though, like his novels, it lacks construction.

Of Gorki's own works, those of his latest period are the best: 'Childhood,' 'In the World,' 'My Universities,' 'Reminiscences of Tolstoi' and 'Fragments from My Diary.' They are all in the old tradition and, like all his work, are powerful documents of acute observation and real truth. Few writers have Gorki's ability to harrow the reader's soul by the intensity of a bitter realism; and few can equal him in the evocation of pity for the outcasts and downtrodden of society. His works are tremendous documents testifying to the social evils of the old Russia; for this alone they are assured of their place in literature. In the same vein is his play 'The Lower Depths.' It has a permanent place in the theatre.

Revolutionary Poets. Russia, like most of Europe, has experienced a decline in poetry since the beginning of the century and, since the Revolution, there has been little improvement. An indefinable malady seems to have struck poetry everywhere. Nevertheless, in Vladimir Mayakovski (1893–1930), Sergei Esenin (1895–1925) and Boris Pasternak (b. 1890) the Revolution found men of genius who continued the old tradition.

Mayakovski's name was established before 1917, but it was after then that he showed fullest development. He tried to speak to the masses, and to do this never hesitated to introduce technical innovations or breaches of syntax in the interests of simplification. He gave his work a truly revolutionary turn and thus attracted the admiration and encouragement of men in power who might not otherwise have noticed him or his verses. He became a propagandist for the new order; having been a poet, he remained one.

Esenin was for a few years far more popular among the masses, though at times his verses so lacked the revolutionary ingredient as to be frowned upon by authority. Most of his work is lyrical, though in 'Pugachev' he attempted (without much success) to write an epic. There is great disillusionment with life in his last verses; this ended in his suicide, an example which was followed five years later by Mayakovski.

Pasternak's poetry is more difficult, more complex, and has a deeper cultural background than that of Mayakovski or Esenin. He is now regarded as a better poet than either, one of the greatest of the New Age. There is freshness in his work, and a sparkle rarely found in that of his contemporaries. It is individual rather than revolutionary.

Drama of Today. The theatre of the New Age, though vast, must be briefly dismissed — because of its quality. In 1933 most Russian critics were bewailing the shortage of good, new plays. Those written to a political pattern enjoyed popularity, for now the masses were able to go to the theatre, which they love. But those new plays were very poor theatre in comparison with the works of Ostrovski, Andreyev, Chekhov and Gorki, and poor enough compared with the works of lesser preceding dramatists. The Government was perturbed and in 1934 organized a competition in the hope of discovering more worthy talent. The result was a disappointment for everybody—not one play worthy of the prize was found in the Soviet Union. By 1940 there was improvement. Encouraged by the State and by the lucrative awards awaiting them, new dramatic authors have begun to come forward. If masterpieces of the theatre are not yet forthcoming, very great promise has manifested itself in such writers as V. Kataev, who wrote 'Squaring the Circle,' A. Afinogenv (d. 1941), author of 'Distant Point,' Konstantin Simonov and Alexander Korniechuk. Simonov has seen action in many sections of the front. His war play, 'The Russians,' was produced by the Old Vic. Korniechuk's most successful plays are 'The Front' and 'Guerillas of the Ukrainian Front.'

In production, acting and staging the theatre in Russia is probably better than anywhere else in the world, and one may entertain the highest hopes for the future.

The Modern Novel. We come now to the outstanding feature of the New Age in Russian literature: the phenomenal growth of the novel. It is as though every writer wished to be a Lermontov, a Tolstoi or a Dostoevski. The novel in contemporary Russia overshadows every other literary form, though the short story sometimes runs it close.

MAYAKOVSKI. Originally a futurist poet, Mayakovski became an enthusiastic supporter of the Soviet régime. Stalin deemed him the best poet of his period.

Photo, S.C.R.

Isaac Babel (b. 1894) carried on the romantic tradition in works of great merit, especially in his famous 'Red Cavalry.' Vsevolod Ivanov (b. 1895), another romantic, wrote of his native Siberia in 'Armoured Train No. 14–69' and other dynamic works. His long novel (it runs to several volumes) 'The Adventures of a Fakir,' fell back on traditional realism. Konstantin Fedin (b. 1892) reminds one of Gogol in his slow-moving, elaborate novel 'Anna Timofevna,' dealing with a woman's life of suffering and sacrifice, while in 'Cities and Years,' he shows great literary talent and notable originality. Leonid Leonov (b. 1899) has for his favourite theme the clash between village and town—some of his characters are so subtly drawn as to remind one of Dostoevski.

Two works of outstanding merit established the reputation of Venyamin Kaverin (b. 1902) —'The Anonymous Artist' and 'Fulfilment of Desires.' Other considerable novelists are Slonimski (b. 1897), Lavrenev (b. 1894), Malyshkin (b. 1890) and Lebedenko (b. 1893). Mikhail Sholokhov (b. 1905) published in 1926 his first great novel 'And Quiet Flows the Don,' a work which, with its successors, 'Virgin Soil Upturned' and 'The Don Flows down to the Sea,' comes closer to Tolstoi's 'War and Peace' than any novel of the period, and places the author among the best novelists of the New Age. These outstanding writers are but a few of those who could be mentioned.

'Proletarian' Literature. No account of the literature of the New Age would be valid without recording the efforts made during some years to create an essentially 'proletarian' literature with a Communist background. This presented many thorny and controversial problems which, in the end, solved themselves by a process of evolution. A group of political doctrinaires and disciplinarians known as 'Onguardists' took exception to much that was being written by the rather too liberal 'fellow-travellers.'

Lunacharski, first Commissar of Education and a playwright himself, Trotski, a political leader and an excellent writer, and also the great Lenin were aware that in the 'fellow-travellers'—mostly bourgeois and non-Communists—resided the literary traditions of the Great Age; that a new culture could not be created in a day; that the new culture must in any case have its roots in the old; and finally that among those whose ideology and proletarian outlook were most correct there were few good writers at that time.

It was Lenin who in the end decided that all culture, and especially all literature that was not dangerous to the régime and the revolution, should be tolerated and even nursed, and efforts or experiments in proletarian literature should be encouraged. This wise decision was not altogether to the liking of the 'Onguardists,' whose literary output was more devoted to downing the 'fellow-travellers' than to the creation of the 'proletarian' literature they advocated. The 'fellow-travellers' defended themselves. Controversies raged, and literature suffered. The best efforts of the proletarian writers proved to be poor literature in comparison with the average work of the 'fellow-travellers.' And that, in the end, decided the issue: from then onwards literature developed in its own way and with far less interference and more encouragement by the State than people outside Russia were prepared to believe.

The position was and afterwards continued to be that, providing an author did not threaten the security of the State, or challenge the fundamentals of Marxism-Leninism and later Marxism-Leninism-Stalinism, or the right of rulers to rule, he could write what he pleased. In actual practice this worked out very well, for although writers were permitted to criticize and did criticize many things, it was mostly constructive criticism; and none wished for any fundamental change in the Soviet system. The Soviet writer began to become a person of importance, with a good status and the possibility of earning a very good income and of enjoying many privileges. As a consequence literature gained in content, and the calling of authorship attracted many aspirants.

For the first time in history the budding author's first struggles were made easier. Output of books increased enormously. Literature expanded. By 1940 the quantity of the literature of the New Age in Russia had reached phenomenal dimensions, and therefore any account of it must needs be utterly incomplete. It would be possible to fill one of these pages with a list of Soviet authors who were then established or at least highly promising; many pages would be required for a list of the titles of their works. Here are some of the most important authors, many of whose works have been translated into English: Valentin Kataev ('Forward, Oh Time!' 'Lone White Sail'), P. Romanov ('Three Pairs of Silk Stockings'), M. Zoshchenko ('The Woman Who Could Not Read,' 'The Wonderful Dog,' and other volumes of humorous short stories), Ilya Ilf and Eugen Petrov (killed in action, 1942), (collaborators in 'Diamonds to Sit On' and 'The Little Golden Calf'), Fedor Gladkov ('Cement'), Makarenko ('The Road to Life'), Yury Herman ('Antonina'), Semyushkin ('Chukotka'), A. Fadayev ('The Nineteen' and 'The Rout'), Furmanov ('Chapayev'), Serafimovich ('Iron Flood'), Pilniak ('The Volga Flows into the Caspian,' 'Mahogany'), Wanda Wassilewska, the Polish wife of Korniechuk, whose 'Rainbow,' an extraordinarily powerful story of the Second World War, won the Stalin Prize in 1943, Lidin, Malashkin, Libedinski, Panferov, Budantsev, Bulgakov, Tikhonov, Bezimenski, Bagritski, Selvinski. One could go on indefinitely.

NOVELISTS OF TODAY. *Leonov (left) has written about many aspects of Soviet life, in such novels as 'The End of a Small Man,' 'The Badgers,' 'The Thief,' 'Sot' and 'Skutarevski.' In 1942 his war play, 'Days of Invasion,' won a Stalin Prize, 1st class. Sholokhov (right) received a similar award for his magnificent novel of Cossack life, 'And Quiet Flows the Don.'*

Photos, E.N.A.

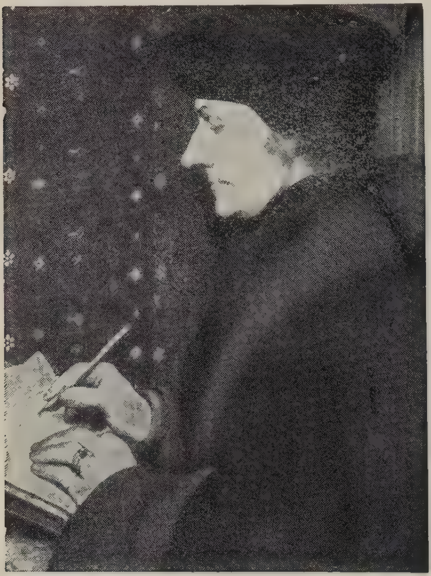
LESSON 18

Dutch, Scandinavian, Finnish

HOLLAND has a rich medieval literature. The French 'roman courtois,' here as elsewhere, produced a crop of imitations, but there were also native lyrics and many religious and didactic poems. The mystic 'Ruusroec' has become world-famous in translation. Drama took much the same course as in other countries; there is a Dutch precursor of 'Everyman,'—'Elderlyk.' In prose, the great theologian Erasmus (1467–1536) wrote copiously, but he used the scholarly Latin rather than the vernacular.

The Renaissance quickened output, but again we note the French influence, to some extent stifling originality. In the 16th century there is little of note, beyond plays and translations from the Psalms. The 17th century, however, was a great period.

Of the many writers who graced this Golden Age, space allows us to mention no more than five. Pieter Hooft (1581–1647) wrote very lovely lyrics and some magnificent plays; he was also a historian. He had travelled widely in France, Germany and Italy and was under the influence of Italian culture. His own influence upon his contemporaries was immense. Gerbrand Bredero (1585–1618), a shoemaker's son,. became a poet and dramatist who pleased the popular taste; his best known play is 'The Spanish Brabander.' Joost van den Vondel (1587–1679) began by translating lyric drama and other verse from the French, Latin and Greek, and went on to write plays which are remarkable for their sublime poetry. His 'Lucifer' is believed to have influenced Milton, who knew Dutch. Jacob Cats (1577–1660) is not a great poet; his importance lies in the fact that he typifies contemporary thought and outlook. His didactic verse, though often it is little better than doggerel, has a homely philosophy and exercised a very considerable influence. The century also gave us the famous philosopher Spinoza (*see* Course on Philosophy, Vol. V, page 153), who wrote voluminously in Latin.



ERASMUS. *Holland's great humanist did much to advance the Revival of Learning. He advocated a return to 'first things' in Christian teaching. His work is mainly in Latin.*

Holbein, The Louvre; photo, Giraudin

The 18th century reflects the influence of English literature. Van Effen (1684–1735) published 'The Dutch Spectator,' a lively imitation of its English prototype. Elizabeth Wolff-Bekker (1738–1804) and Agatha Deken (1741–1804), writing in collaboration, brought out novels in epistolary form, modelled on those of Richardson, but more finished.

The 19th century was heralded by Willem Bilderdijk (1756–1831), a distinguished poet and a noble character. Another writer whose sound thinking and frank expression made a strong impression was Multatuli (1820–87), whose real name was Eduard Doúwes Dekker. His completely natural prose brought about a revolution in Dutch literature, and is seen in the largely autobiographical 'Max Havelaar.'

Modern Dutch Writers. There has been, since 1880, a great flowering of Dutch literature. The poets include Willem Kloos, Jacques Perk and Herman Gorter. Frederik van Eeden (b. 1860) wrote poetry and plays but excelled as a novelist; his 3-part 'Little Johannes' and 'The Deeps of Deliverance' have been translated. An outstanding novelist is Louis Couperus (1863–1923), whose work has been extensively translated; he is best known for his 'Books of the Small Souls'

(1901–3), 'Old People and Things That Pass' (1906) and 'The Comedians' (1917). 'Iskander' (1920) is a fine historical novel dealing with Alexander the Great. Louis Couperus shows a real mastery of his themes, which he handles with Tolstoyan imagination. He has also written masterly short stories, sketches and essays.

Another Dutch writer who is well known in this country is Jan Fabricius (b. 1871), dramatist and novelist. He is often prolix and lacking in literary grace, but he has verve, and 'The Son of Marietta' was a deserved success. Israel Querido (1874–1932), a distinguished critic, has won popularity as a novelist, and Herman Heijermans (1864–1924) will be best remembered here for his fine novel 'The Rising Sun' and for a powerful short play, 'A Case of Arson.'

COUPERUS. This famous Dutch novelist wrote delightful stories of his own land and also reconstructed ancient times in glowing prose. He was a prolific writer.

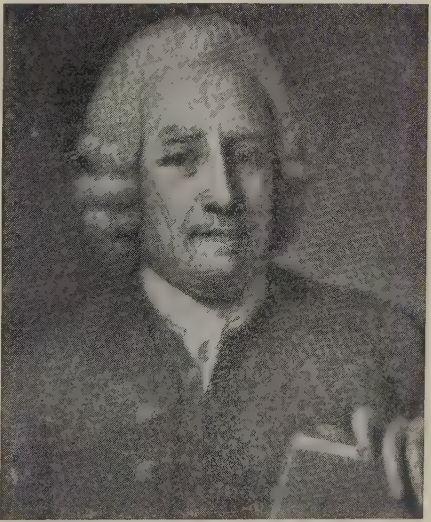
Scandinavian Literature. The literature of Scandinavia begins with the Icelandic Eddas, which fall into two groups. The Elder Edda, or Poetic Edda, consists of epic poetry, often fragmentary, narrating the primitive myths and early history of the Norse settlements. Here we find the first mention of the Volsungs and the Nibelungs, whose stories have inspired so much magnificent literature. This material was collected in the 12th century, but much of it dates from two or three centuries earlier; it was not made known to the world until 1643. The Younger Edda, or Prose Edda, was collected, and probably rewritten, by Snorri Sturluson (1179–1241), a poet whose greatness has been unmatched in Scandinavian literature down to our own times. This Edda includes a sort of treatise on poetry, with rules.

Icelandic Sagas. There is also a vast amount of saga material, mainly Icelandic—and dating from the 12th century. The sagas are prose epics, based on the old legends. Snorri Sturluson's mighty 'Heimskringla' enshrines many of them. Famous, too, are 'The Grettir Saga,' 'The Njal Saga' (Burnt Njal), and the romantic 'Saga of Laxsdael,' which gives the story of Gudrun.

It should be noted that Icelandic literature has continued since the days of the first Scandinavian settlements. In our own time, the fine work of Gunnar Gunnarson (b. 1889) is available to us in translation. Distinguished both as poet and novelist, Gunnarson has written in Icelandic and in Danish. His best known works are 'Guest the One-Eyed,' 'Seven Days' Darkness' and 'The Sworn Brothers.'

Early Swedish. In early Swedish literature the most interesting work was done by religious writers, of whom Saint Brigitta (1303–73) is most notable. Father Mattias (d. 1350) began a fine translation of the Pentateuch which was completed by Johannes Bude (d. 1494). In the 17th century the poet Stiernhelm (1598–1672) was extremely influential; his epic 'Hercules' is a great achievement.

During the 18th century the outstanding literary figure under the dual Dano-Norwegian monarchy was Baron Ludwig Holberg (1684–1754), who, besides writing on historical and philosophical subjects, was an accomplished dramatist. In Sweden there were two personalities whose influence has


SWEDENBORG. A brilliant Swedish scientist, Swedenborg was unable to explain the spiritual nature of man and gave up his career in order to meditate. He claimed to have received direct revelation and embodied his beliefs in many mystical works.

been world-wide,—Emanuel Swedenborg (1688–1772), scientist and mystic, and Linnaeus (1707–78) the great botanist; both wrote in Latin but were widely translated. Johann Kellgren (1751–95) and Thomas Thorild (1759–1808) brought to the North the classicism of the great French writers and the pre-Romanticism of Rousseau. The Swedish Academy was founded in 1786 by Gustavus III, himself a fine playwright; it was modelled on the French Academy, but had 18 members instead of 40.

Danish Romanticism. It was in Denmark that Romanticism was best exemplified. Johannes Ewald (1743–81) is among the great lyric poets of the world; his ' Balder's Death ' has been translated. In 1775 he founded the Danish Literary Society. Adam Oehlenschläger (1779–1850), poet and dramatist, was publicly crowned ' Scandinavian King of Song ' in 1829. Of his many volumes of poetry, ' The Golden Horns,' ' Axel and Valborg ' and ' The Gods of the North ' are known to us in translation, as also his delightful fairy-tale drama, ' Aladdin.' Hans Christian Andersen (1805–75), another Dane, earned undying gratitude for his immortal ' Fairy Tales '; he was, too, a successful writer of novels, travel-books and plays. Ranking with Andersen and the German Grimm brothers as writers of fairy-tales, we must note Peter Asbjörnsen (1812–85) and Jörgen Moe (1803–82) in Norway; both were learned in folk-lore, and their collaboration produced the great collection of ' Norwegian Folk Tales ' which has been frequently translated; in English, Sir George Dasent's version is best known.

IBSEN. A great dramatist and a great social reformer, Ibsen was also a poet and a thinker. His approach to a problem was not merely realistic but lit by imagination, and he had the mystic's apprehension of spiritual values. He was born in S. Norway in 1828.

BRANDES. This celebrated scholar was for many years excluded from a professorship at Copenhagen because of his modernist views and Jewish origin. His outspoken ' Danske Gigtere ' led to his exile, but later he received high honours.

During this period, Sweden's outstanding writer was Esaias Tegnér (1782–1846), a professor who was one of the leaders of the Gothic League, a group of young literary men meeting in Lund. Tegnér entered the Church and became a bishop. His best work is in ' Axel ' and ' Frithiof's Saga,' which have been translated. The Finnish poet Johan Runeberg (1804–77) wrote largely in Swedish; his ' King Fjalar ' and ' Ensign Stahl's Adventures ' have been translated. The latter contains the poem 'Our land, our land,' Finland's national song.

Four Great Writers. The latter part of the 19th century was a great period in Scandinavia. Denmark had in Georg Brandes (1842–1927), a Jew, one of the most influential of European critics. In Norway, Henrik Ibsen (1828–1906) and Björnstjerne Björnson (1832–1910) aroused interest throughout the world by their social dramas. In Sweden, August Strindberg (1849–1912) dominated literature for at least fifty years.

One must dwell for a moment on these four writers. Brandes' most famous work is the 6-volume ' Main Currents in Nineteenth Century Literature,' first delivered as a series of lectures. It was a frontal attack on the existing literary situation in Denmark. At the same time it provided a standard for valuation and for new creative

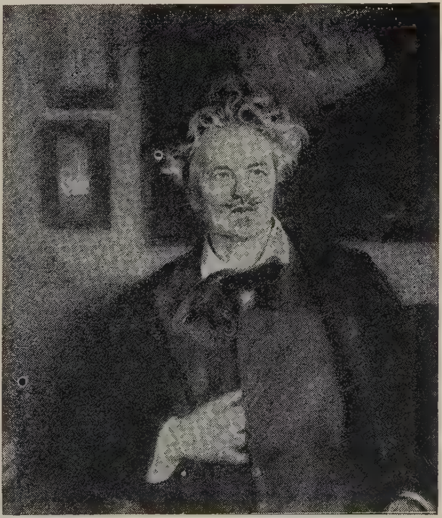
BJÖRNSON. *After attracting attention by his vigorous stories of peasant life, Björnson became famous for his great historical plays. He was also a poet and wrote the Norwegian national anthem. Uniformly successful, he was a national hero. This is a death mask.*

work. Brandes proclaimed that the aim of literature is reality, not dreams; that the author is a responsible person who must take himself seriously and provide food for thought and not just a means of killing time. In a sense, he was a 19th century Humanist, one whose vision embraced the amazing developments and potentialities of the Industrial Revolution and the ethics springing from the works of such writers as Darwin and Nietzsche. Art, he taught, must not be satisfied with the ideas and ideals of mediocrity; great art seeks a defiant independence and an 'aristocratic absolutism.' Brandes became a European celebrity. His many volumes of essays, biographies and expositions have influenced writers of every country.

The revolutionary plays of Ibsen provided the impetus for changes in the social outlook of Europe. He attacked existing conventions and the hypocrisy of bourgeois society. Because of his mastery of dramatic technique, Ibsen may be called the father of the modern drama; 'A Doll's House' is a model for playwrights. In the disciplined dramatic form he could compress wide-sweeping material. The long list of his plays includes 'Lady Inger of Ostraat' (1854), 'The Warriors at Helgeland' (1858), 'Love's Comedy' (1858), 'The Pretenders' (1864), the great dramatic poems 'Brand' (1866) and 'Peer Gynt' (1867), 'The League of Youth' (1869), the vast 2-part 'Emperor and Galilean' (1873), 'Pillars of Society' (1877), 'A Doll's House' (1880), 'Ghosts' (1881), which caused a storm because of its outspoken exposure of the hereditary nature of venereal disease, 'An Enemy of the People' (1882), 'The Wild Duck' (1884), 'Rosmersholm' (1886), 'The Lady from the Sea' (1888), 'Hedda Gabler' (1890), 'The Master Builder' (1892), 'Little Eyolf' (1894), 'John Gabriel Borkman' (1896) and 'When We Dead Awaken' (1900). It is a magnificent series, which have been translated by William Archer.

A most prolific author who was regarded as the outstanding figure in Norwegian literature at this time, Björnson wrote plays, poetry, novels and short stories. It is as a dramatist that he is best known. In romantic drama he wrote four plays on Sigurd the Bastard and a fine tragedy on Mary Stuart; his amusing comedy, 'Newly Married,' still holds the stage; his symbolic drama, 'Beyond Our Powers,' had a great success; and, like Ibsen, he also wrote social drama with a purpose. Björnson's poetry has real beauty. As a novelist, he began with stories of peasant life and ended with realistic stories. His work has been translated in its entirety, and earned the Nobel Prize in 1903.

Strindberg is Sweden's greatest dramatist, whose most famous plays, 'The Father,' 'Countess Julie,' 'The Creditors' and 'The Dance of Death,' are undoubtedly works of genius, though their morbid pathological themes and the bitter intensity of treatment prevents them from winning popularity on



STRINDBERG. *At first a novelist, Strindberg was unpopular because of his satirical pictures of society and his cynical attitude towards marriage and religion. He won fame far outside Sweden by his plays.*

From the painting by Richard Bergh

TWO FAMOUS WOMEN NOVELISTS. Sigrid Undset (left) is an outstanding figure in contemporary Norwegian literature, as is Selma Lagerlöf (right) in Swedish. Both have received the Nobel Prize. Their work, which has an epic sweep, is finely disciplined and marked by a noble integrity.
Photos, E.N.A.

the stage. Strindberg made three unhappy marriages, and was at one time perilously near insanity; his work reflects the mental torments he endured. He was, however, capable of much grace and humour, as may be seen in some of his excellent short stories. A most versatile writer, he produced several fine novels, of which 'The Red Room' is unequalled in its mordant criticism of contemporary society.

As Ibsen and Björnson are called the fathers of modern Norwegian drama, so Jonas Lie (1833–1908) is justly called the father of the modern novel in Norway. His first novel, 'The Visionary,' attracted attention and was followed by 'The Barque "Future",' 'The Pilot and his Wife,' and other novels, until in 1882 'Go Ahead!' showed that here was a writer of the highest importance. In 'A Maelstrom' and 'A Marriage' he maintained the same high standard, and his two volumes of short stories, 'Trolls,' proved him to have a wide range and a sure touch.

Another outstanding writer was Alexander Kielland (1849–1906), whose first book, 'Novelletter,' won immediate popularity; he wrote a considerable number of successful novels and plays.

Each Country its own Course. When we reach the 20th century, we find that each of the three Scandinavian countries pursues a course of its own. They have one great quality in common: integrity. The influence is partly that of Brandes. Scandinavian writers of this century do not concern themselves with vulgar tastes, they do not provide 'escapist' literature for the masses. They write with sincere artistic purpose, out of their hearts, not imitating successful foreign writers. They reflect conscientiously what

NORWEGIAN NOVELISTS. Jonas Lie (left), a lawyer by profession, was the first of the modern Norwegian novelists; he had much encouragement from Björnson. Many of his stories deal with seafaring life. Knut Hamsun (centre), who was of humble birth, had a hard struggle to earn his living in various occupations, until 'Hunger' brought him success. Johan Bojer (right) won recognition in his early twenties and his work has been unfailingly prolific and popular.
Photos, E.N.A.

they know from their own experience. Thus, 'fiction' to them does not mean the ingenious stringing together of adventures, sensational episodes or sentimental chronicles. What it does mean is an interpretation of events and personalities that is completely consistent with knowledge and reason.

Great Women Writers. A perfect example of this integrity is the great Norwegian authoress Sigrid Undset (b. 1882). In her youth she supported herself by doing clerical work for small pay, living the humdrum existence which she was afterwards to depict so faithfully in her novels. She had none of that sensational success which often comes to the young writer in England or America, but by dint of hard work gradually gave the world book after book, each of which indicated the sure development of a fine mind and an exceptional artistic talent.

In 1911 she published 'Jenny,' a novel which won the full approval of her own country's critics, and extended her fame abroad. Her most important work is in the two great cycles, 'Kristin Lavransdatter' and 'The Master of Hestviken,' romances of the remote saga period written with a realism, a breadth of knowledge, an imaginative sympathy and a wide sweep that compare with the work of the leading Russians. Sigrid Undset is an important addition to European literature, though there could be no more intensely Norwegian writer. In 1928 she was awarded the Nobel Prize.

Another great writer is Selma Lagerlöf (1858–1940), a Swedish woman who received the Nobel Prize in 1909. Her most popular work is 'Gösta Berling's Saga,' a lengthy modern prose epic, teeming with characters, vast in scope and written in a style that is both lyrical and thrilling. Yet her short stories and her long novel 'Jerusalem' are even better literature. Many of her books are available in translation.

20th Century Unrest and Flux. The 20th century for Denmark, Norway and Sweden brought new values and a period of unrest and flux. In the first two countries, the chief characteristic is the rôle played by proletarian and peasant writers of the soil, among whom Andersen-Nexo and Knut Hamsun may be instanced. In Denmark the most important novelists are Johannes V. Jensen (b. 1873), whose 'Danes' and 'The Fall of the King,' 'The Long Journey' and 'The Cimbrians,' together with his series of 'Himmerland Stories,' entitle him to a place of honour among European writers; and Henrik Pontopiddan (1857–1943) who wrote stories of country life, of which 'The Promised Land' has been translated. Martin Andersen-Nexo (b. 1869) won much popularity; his 5-volume 'Ditte, Daughter of Man' has been translated. The greatest of modern Danish poets was Karl Gjellerup (1857–1919), who in 1917 shared the Nobel Prize with Pontopiddan.

In Norway, Knut Hamsun (b. 1859) and Johan Bojer (b. 1872) are excellent novelists. Hamsun's success dates from 'Hunger' in 1890 and has been consistent; he was awarded the Nobel Prize in 1920. Bojer's finest work is probably in 'The Power of a Lie' (1903) and 'The Great Hunger' (1916).

In Sweden Romanticism is combined with Realism and tinged with a gentle scepticism that is well exemplified in the work of Hjalmar Söderberg (b. 1869). This attractive novelist has a keen eye for human weaknesses, including his own. He is at his best in the short story, of which he published several collections, notably 'Doctor Glas.' He also wrote three excellent plays: 'Gertrude,' 'Evening Star' and 'The Hour of Fate.' The two other modern Swedish authors worthy of mention are Hjalmar Berhman (b. 1883) and Anders Österling (b. 1884), leaders of the new generation, whose work is always interesting and often sparkling, though never profound.

A sceptical pessimism has spread through Swedish literature, with the result that objectivity is lost and the spirit of life is lacking. This is no doubt due to the easy comfort of Swedish life, in which there was not, until the Second Great War, any 'storm and stress' to stimulate authors to deeper efforts.

Finnish Literature. The literature of Finland has been, until the 20th century, outside the general European currents. Authors have been satisfied with simple local themes, and the public is satisfied with imported literature, though in the few years preceding the Second Great War there were signs that young writers wished to show a native originality. The national epic known as the 'Kalevala' or 'Land of Heroes' remains the one outstanding work of literature which this country has produced. Of Finland's modern writers, the most gifted was Juhani Aho (1861–1924). He follows the French realists in his treatment of contemporary life, and his best works are 'Enris,' 'The Fortress of Matthias' and 'Finland's Flag.' Aho set the fashion down to our own times. For the rest, Finnish literature is chiefly influenced by Swedish. Madame Aino Kallas has done distinguished work as a Finnish-Estonian novelist and playwright and is known to us in translation.

LESSON 19

Polish and Other Literatures

BEFORE the 16th century most Polish authors wrote their works in Latin. The only old work in Polish of other than historical or philological importance is the Bible, which is said to have been translated for Queen Sophie about the year 1455. Even this translation is incomplete. It was not until the poet Jan Kochanowski (1530–84) had set an example to his fellow-countrymen by writing in the Polish language his very beautiful 'Lamentations' on the death of his daughter that we meet anything worthy of the name of native literature. By this work and others in verse, including a play in iambics called 'The Despatch of the Greek Ambassadors' (incidentally, the first important drama in the language) Kochanowski came to be called the Prince of Polish Poets.

Even more important than the intrinsic literary worth of his poetry is the fact that it inspired many other would-be poets to turn to their mother tongue as a medium, and abandon the prevalent and somewhat snobbish fashion of writing in an ancient language that is ill suited to their psychology. Kochanowski's poetry, considerable in volume, holds an important place today in the anthologies. His epigrams, not unlike those spirited, witty sayings which are sprinkled throughout 'Don Quixote,' are possibly even more esteemed. We must date modern Polish literature from him.

Mickiewicz and his Epics. Although many names could be cited to show that the new literature was developing, it is not until about 200 years later that we come to a period in which Polish literature can stand any serious comparison with the literatures of the countries we have already surveyed. The outstanding name of this relatively rich period is Adam Mickiewicz (1798–1855). He is considered to be the greatest Slavonic poet after the Russian Pushkin, whose friend he was. Mickiewicz is undoubtedly Poland's greatest poet and, if his name is little known outside his own country, it is because few foreigners take the trouble to learn its difficult language. Like the work of Pushkin, that of Mickiewicz is very difficult to translate.

His themes are for the most part essentially national: Poland's history, legends, superstitions, folklore and struggles. His sonnets, especially, are very beautiful, though 'Pan Tadeusz,' a long narrative poem dealing with a national hero, is his most popular work and probably his masterpiece. 'Konrad Wallenrod,' another epic, is almost its equal. In these fine epic poems he shows wonderful powers of description, and because of them some have compared him to Wordsworth. For a time Mickiewicz held the chair of Slavonic studies in Paris, and during that period published four volumes of literary history and criticism. They are little read now. He had become immersed in religious mysticism and the resultant medley is of little importance either as criticism or as mysticism. There are translations of 'Pan Tadeusz' and 'Konrad Wallenrod.'

The second great Polish poet after him is Julius Slowacki (1809–49), a Romantic who was influenced by Byron and Victor Hugo. His finest pieces are 'Hugo,' 'The Monk,' 'Lambro,' and a Dantesque work called 'Anhelli.' As in so many other countries, poetry in Poland developed more rapidly than prose.

Growth of the Novel. The first popular novelist was Joseph Korzaniowski (1797–1863). Joseph Ignatius Kraszewski (1812–87), another and possibly a better novelist, had a prodigious output. A mere selection from his fiction was collected and published in the eighteen seventies. It consists of no fewer than 102 volumes! Again, in comparison with the great novels that were being written in other countries, the work of these two Polish writers is not important. There is nothing original about it, and the most that can be said in its favour is that both authors showed that they could use their language with fluency, often with great felicity, and that they could tell a tale. Strangely enough, the work of Kraszewski today considered to be of most value is in national archaeology and aesthetics, not literature.

No important novelist appears until we meet Henryk Sienkiewicz (1846–1916). He has the honour of being the first author of his nationality to achieve a European reputation. It is by the novel 'Quo Vadis?' that Sienkiewicz is best known throughout the world. This book appeared in 1895 and in English in 1896. It is a study of Roman society under Nero, with special reference to the tribulations of the Christians. The general picture is convincing, the scholarship good. But it is in his remarkable powers of realistic reconstruction and description that the author excels, and this quality, together with the ability to tell a moving and in parts a religious story, brought the book success not only in Poland but among the peoples of the thirty languages into which it was translated. It has been dramatized and filmed; the story is perennial.

As is so often the case with authors of a best seller, 'Quo Vadis?' is not Sienkiewicz's best work; this is a fine trilogy consisting of 'With Fire and Sword,' 'The Deluge,' and 'Pan Michael,' written in a stately prose. His vigorous 'Teutonic Knights' appeared in English translation in 1943.

Modern Period. The success of Sienkiewicz focused an attention on the novel which had hitherto been devoted to poetry, though the greatest poet of modern Poland, Jan Kasprowicz (b. 1860) was never sufficiently moved by it to turn to prose. Stefan Zeromski (1864–1925) and Wladislaw Stanislas Reymont (1867–1925)—the latter a Nobel Prize winner—wrote little but novels. There can be no concealment of the fact that Zeromski deliberately followed and imitated Sienkiewicz, though he chose different themes. His most successful work is 'The Ashes,' a novel dealing with the Napoleonic period. Reymont has been called the Polish Zola. His best work is a tetralogy that has been translated into English under the title of 'The Peasants.' It may well be that posterity will say this is the greatest novel Poland has so far produced, because of its accurate psychology.

Between the two World Wars the number of poets decreased; that of prose writers increased. Only one name among the latter is outstanding; Ferdinand Ossendowski. His books relating very amazing experiences in a very remarkable manner won him a worldwide popularity. In the hurly-burly of the re-establishment of a new State, authors who might have been producing literature turned to national problems. Literature suffered. There has not yet been a 'Golden Age' of Polish literature. Such a period remains for the future.

Czech Literature. Czech literature is comparatively new—one hundred years ago there was little of it, apart from some interesting lyrical poetry. By about 1850, but hardly before, there was a reading public for works in the Czech language. F. L. Čelakovskí (1799–1852) made an important collection of old Czech songs, and the relaxation of Austrian rule in 1850 encouraged printers, publishers and nationalist authors to disseminate old traditional works and attempt to produce new ones. Among the important 19th century authors was Jan Neruda (1834–91), who wrote interesting stories of middle-class life in Prague.

The greatest name in Czech literature is that of Jaroslav Vrchlickí (1853–1912), who probably holds the world's record for poetic output, with no less than 70 volumes. To him must be given the honour of stimulating the public appetite for literature in the mother tongue, which he enriched and proved to be an admirable literary medium. Furthermore, he was responsible for a vast output of translations from other languages; this in itself gave a great impetus to the new nationalist literature. Poetry developed more quickly than prose, as in other countries.

In 1895 a 'Modernist Manifesto,' signed by a group of poets, called upon writers to observe a code not very dissimilar from that enunciated by the great Danish critic Brandes. This was the real beginning of modern Czech literature. Its greatest exponents have been J. S. Machar (b. 1864), Otakar Březina (b. 1868), Fráňa Sràmek (b. 1877)—all of them little known outside their own land.

Two Czech writers of our times achieved world-wide reputations. The first, Karel Čapek (1890–1938), is best known in England for his remarkable dramas 'R.U.R.' and 'The Insect Play' (the latter, and another play, written with his brother Joseph) as well as for 'Letters from England' and other travel books, novels and short stories. The second is Jaroslav Hašek (1884–1923) who before the First Great War had published many short stories, and after it began 'The Good Soldier Schweik'—a Gargantuan satire which did much to encourage Czech nationalism. Only four of the projected six parts were written. This book had an extraordinary popularity throughout Europe in the nineteen twenties and, although uneven, contains many passages of conspicuous virility. The grand comic conception is endowed with a quality of greatness which puts it in a class by itself among the literatures of the smaller nations.

Hungarian Literature. Hungary is to be numbered among the few countries in which a king laid the foundations of a national literature by precept and practice. To the Hungarians, the name of King Matthias Hunyadi (*c.* 1458–90) is that of an immortal, for he it was who evoked the slumbering forces of the national poetic genius, and from his time until today, with many periods of progress and many of vicissitudes, there have never ceased to be authors who worthily used their difficult language. Yet only in the novel have Hungarian writers extended their fame outside their own country, and then not to any great extent. The Hungarian novel shows none of the originality to be found in the novel in the bigger countries.

Maurus Jókai (1825–1904) is perhaps the most popular novelist Hungary has produced, and it is claimed for him that there has been no more brilliant narrator since the 'Arabian Nights.' His best works deal with the life which he found around him. Perhaps his best novel is 'The New Landowner,' a delightful and witty picture of the absolutism introduced by the Austrians after their seizure of the country. His 'Hungarian Nabob' depicts the aristocracy in all its haughtiness and insolence, while the hostile, revolutionary attitude of the Hungarians towards their Austrian masters is shown in 'The Baron's Sons,' 'Political Fashions' and 'Battle Pictures.' In his 'Novel of the Coming Century' he gives highly prophetic descriptions of modern warfare, including a battle in the sky between two airships.

Kálmán Mikszáth (1849–1910) is the only Hungarian novelist who can be compared with Jókai, and then only because of one novel, 'The New Zrinyiász,' in which the hero Zrinyi rises from his grave to find himself in the altered conditions of the new Hungary.

Before the Second Great War there was a quantitative renaissance; quality did not reach the standards of the authors mentioned. For all that, there was every sign that quality was improving and that there were sufficient writers of Hungarian to promise good things in the future.

BOOK LIST

General. 'Periods of European Literature,' ed. G. Saintsbury (Blackwood, 12 vols.); 'Dictionary of European Literature,' L. Magnus (Routledge); 'Studies in European Literature,' Janko Lavrin (Constable); 'Main Currents in Nineteenth Century Literature,' G. Brandes (Heinemann).

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PHYSIOGRAPHY

Physiography is the explanation in general terms of the natural phenomena which, in differing combinations, make up the particular geography of the different regions of the world. As seen in this Course it includes what is known about the position of the earth in space; about the surface of the earth and its nature, and how measurements are made on it and maps of it constructed; about the weather conditions that affect the earth; and about rivers, oceans, and glaciers and their behaviour.

Knowledge of the underlying principles of physiography is a desirable preliminary to the study of geography, and the brief Course which follows is intended to give the student the necessary elementary insight into the subject. It is recommended that it should be read in conjunction with the Courses on Geography *and* Economic Geography *in Vol. VI. Fuller information on certain of the phenomena affecting physiography will be found in the Course on* Geology *in this volume.*

12 LESSONS

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LESSON ONE

The Earth and its Position in Space

The earth is a sphere, revolving round the sun. A familiar illustration of its spherical shape is that of a ship near a lighthouse set on a steep rocky coast. To an observer on the ship, the top of the lighthouse appears first. As the ship nears the coast, the whole of the lighthouse and then the cliff down to the waterline gradually become visible. Another illustration is the always circular shadow of the earth during an eclipse of the moon. These, however, are only illustrations. For actual proof we must obtain the assistance of the astronomer and the mathematician.

If the earth were a true sphere, its equatorial diameter (a straight line connecting two points on the equator, and passing through the centre of the earth) would be equal to its polar diameter (a straight line joining the north and south poles). This, however, is not the case, as the earth is slightly flattened at the poles.

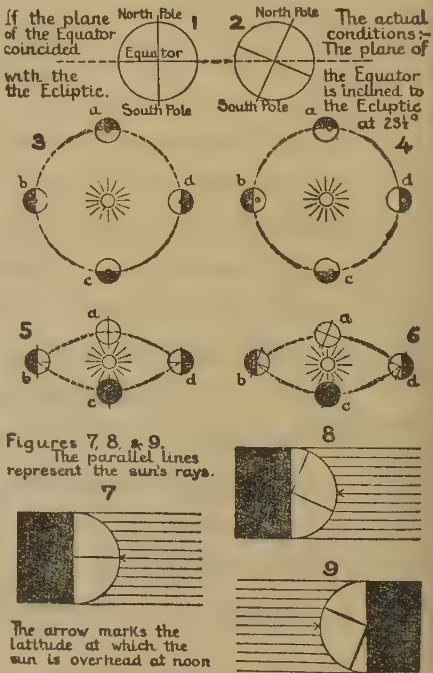
A pendulum clock is regulated by lengthening the pendulum (to make the clock go more slowly), or by shortening it (to make it go faster). In 1672, the French astronomer Richer found that a clock which kept accurate time in Paris (49° N. Lat.) lost 2 minutes a day at Cayenne (5° N. Lat.). Sir Isaac Newton explained that this was due to the fact that a pendulum swings faster the nearer it is to the centre of the earth. As the clock lost time at Cayenne, that place must be farther from the centre of the earth than Paris. This can be explained only by the conclusion that the farther a place is from the equator the shorter will be the earth's radius measured at that point. As a matter of fact, the equatorial diameter is 7,926 miles, 27 miles longer than the polar diameter (7,899 miles).

Earth's Two Movements. The earth has two principal movements. These are as follows: (1) It revolves round the sun once in a year and a few hours, moving in an anti-clockwise direction. (2) It rotates on its polar axis once in 24 hours, in a direction which may perhaps be best described by saying that the place in which the reader lives travels east.

The earth's path round the sun is not a circle, but an ellipse, with the sun in one of the two foci, so that there will be a point of the earth's closest approach to the sun (perihelion) and, six months later, the point of its greatest distance (aphelion). The ellipse, however, is so nearly a circle that the difference between the earth's distances from the sun at perihelion and aphelion is only about one-sixtieth of the greater diameter of the earth's orbit.

The only effect on our climate of this difference is, as we shall learn in a later Lesson, to make the summers in the southern hemisphere slightly warmer than those in the northern hemisphere. It is the annual motion which really affects our climate. Not only does it give us those variations of temperature at different parts of the year, which we call seasons, but it also produces the varying relative length of day and night at different times of the year.

The plane in which the earth travels round the sun is called the *ecliptic*. If the


If the plane of the Equator coincided with the the Ecliptic.
North Pole
1
Equator
South Pole
2
North Pole
South Pole
The actual conditions:– The plane of the Equator is inclined to the Ecliptic at 23½°
3
a
b
c
d
4
a
b
c
d
5
a
b
c
d
6
a
b
c
d
Figures 7, 8, & 9. The parallel lines represent the sun's rays.
7
8
9
The arrow marks the latitude at which the sun is overhead at noon

EARTH'S MOVEMENTS. *Figs. 1-9. Diagrams illustrating the plane of the equator and the ecliptic.*

earth's axis were perpendicular to the ecliptic, the plane of the equator would always coincide with the ecliptic (Fig. 1); in other words, no point of the equator would ever be above or below the ecliptic. This, however, is not the case, as the plane of the equator is inclined to the ecliptic at an angle of 23½° (Fig. 2).

In order to make the conditions resulting from this quite clear, we will first consider what the conditions would be if the plane of the equator *did* coincide with the ecliptic. These conditions are illustrated by the four left-hand diagrams, while the five on the right show the conditions arising from the inclination of 23½° which has just been referred to.

Assuming that the earth's axis is perpendicular to the ecliptic, it must, when viewed, as it were, from above (Fig. 3), point directly at the observer, and the point on the earth's surface nearest to him will be the north pole, marked in our diagram by a dot within a circle. For present purposes it will suffice if we examine only four positions of the earth on its annual journey round the sun.

Fig. 5 is what we may call a side view, drawn in perspective. Both Figs. 3 and 5 show the same thing—that the sun, under the conditions we are considering at present, will always be overhead at noon to an observer on the equator, and that the line on the earth's surface dividing day and night will always pass through the poles. In position *a* of Fig. 5 we see only that half of the earth which is turned to the sun, and is illuminated, while in position *c* we see only the other (dark) hemisphere. It will now be clear that the conditions shown, on a larger scale, in Fig. 7 would exist all the year round in the imaginary conditions which, for the sake of our argument, we are assuming.

We now turn to the right-hand diagrams, which illustrate the actual conditions, with the earth's axis tilted at 23½°, as shown in Fig. 2. A comparison of the position of the north pole in Figs. 4 and 6 with that in Figs. 3 and 5 respectively will make it clear that only in positions *a* and *c*, and only on two days in the year, will the dividing line between day and night pass through the poles, giving the conditions shown in Fig. 7. In position *b* the sun's light travels beyond the north pole, leaving the south pole in the dark (Fig. 8). In position *d*, on the other hand, the south pole has daylight, while the north pole is in the dark (Fig. 9).

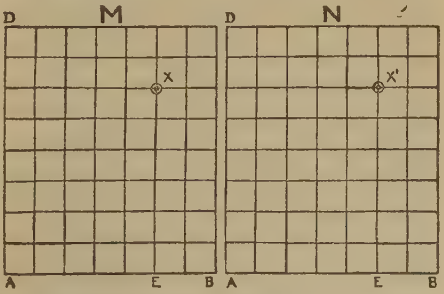
LESSON TWO

Latitude and Longitude

The position of any place on the globe may be stated by naming its latitude and longitude. On any atlas map, the lines drawn from west to east are parallels of latitude, those drawn from north to south are called meridians.

In Fig. 10 we see two pieces of paper, M and N, ruled in squares. On M is marked a point X. You can mark a point X′ in the same position on paper N by counting 5 intervals from A to E, and 6 intervals from E to X′. That is exactly what one does in fixing the position of a place on the globe by its longitude and latitude. AE represents longitude east of the meridian AD, and EX represents latitude north of AB.

The angle formed by the polar diameter and any radius of the equator is a right angle (90°). Divide this angle into 9 equal parts (10° each), and produce the dividing lines to the surface of the globe. Through the ends of these lines draw circles round the globe, parallel to the equator. These are the parallels of latitude, and all points on any one of them will be the same distance from the equator, measured along the meridians passing through them. The larger a globe or map, the more parallels of latitude shall we be able to draw on it, at intervals of 10°, 5°, or even 1°, and the more accurately shall we be able to put a place in its correct latitude, either by eye, or by actual measure-



LATITUDE AND LONGITUDE. Fig. 10. Diagram showing principle of calculation (see text).

ment between the two nearest parallels. Latitude is stated in degrees, minutes, and seconds, north or south, from the equator (0°) to the two poles (90°), 60 seconds being equal to one minute, and 60 minutes to one degree.

In addition to the parallels of latitude drawn at varying intervals, according to the scale of our globe or map, four others play an important part in connexion with the changes of the seasons, and the varying relative length of day and night.

We have already learnt that the earth's axis is not vertical to the ecliptic, but is out of the perpendicular by 23½°, with the result that twice during the year the sun is overhead at noon to an observer either 23½° north or 23½° south of the equator. When this occurs, the sun appears to be in one or other of the constellations Cancer and Capricorn. Hence the two parallels 23½° north and south of the equator are named respectively after these constellations (*see* Fig. 11).

When the sun is overhead at the equator, the dividing line between day and night passes through the poles (Fig. 4). Obviously, when it is overhead at one of the tropics (Figs. 8 and 9), that dividing line will pass through two points 23½° from the poles. The two parallels of latitude drawn through these points are called respectively the Arctic (north polar) circle and the Antarctic (south polar) circle, as shown in Fig. 11.

(The explanation of the word tropic will be given in the next Lesson.)

Latitude and the Pole Star. The latitude of a place may be determined by means of astronomical observation. The Pole Star (Polaris) is a fixed star only 1½° from a line continuing the earth's axis beyond the north pole. It is at such an enormous distance from the earth that to two observers placed as far apart as possible on the earth, namely, at opposite ends of an equatorial diameter, it appears in the same direction. For the same reason, the 1½° referred to above may be disregarded, and the Pole Star taken to be exactly over the north pole. To an observer looking north from any point on the equator, the Pole Star appears low down on the northern horizon.

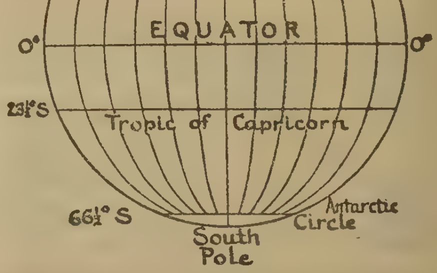
If he travels north, the Pole Star will appear to rise above the horizon, until, when he reaches the pole, it will be overhead. As the latitude of the north pole is 90°, this means that the star has appeared to rise one degree for every degree of latitude travelled by our observer from the equator (0°) to the pole (90°). Consequently, the latitude of any place on the northern hemisphere can be determined by observing the height above the horizon, or 'altitude,' of the Pole Star. On the southern hemisphere, latitude can be determined by similar observation of two stars in the constellation known as the Southern Cross.

Latitude tells us the distance of any place on the earth from the equator in degrees, measured along a meridian. As it counts from the equator, and as there is only one equator, 15° North Latitude means the same thing whether on a British or any other map.

Longitude. Longitude is the distance east or west of any given meridian. Now, as the number of meridians which it is possible to draw on a globe is theoretically infinite, to avoid confusion the meridian of the Greenwich Observatory has been fixed upon by the countries of the world, with very few exceptions, as the meridian of 0° of longitude, and distances are measured east and west up to the meridian of 180° on the opposite side of the earth.

Look at any map in your atlas, and you will find that the degrees of longitude are numbered in such a way (along the top and bottom of the map) that the figure '0°' will fall on the Greenwich Meridian, which we therefore call the primary meridian.

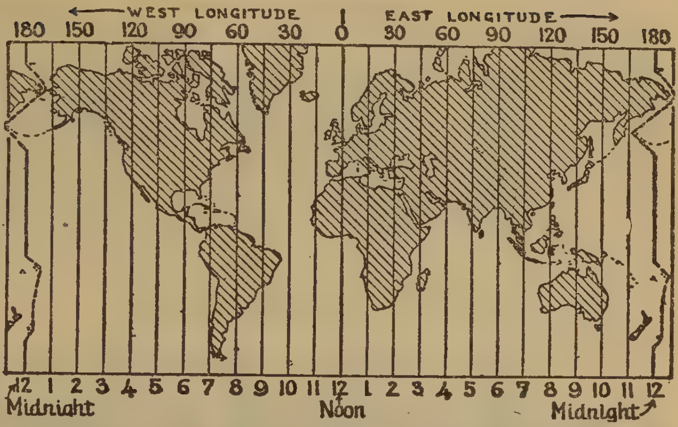
All parallels of latitude, as well as the equator, can be divided into 360 degrees, so that although obviously the length of a degree of longitude becomes smaller as we move away from the equator, the number will always be the same. This means that we can measure longitude either along the



PARALLELS. Fig. 11. Four principal parallels of latitude, measured in degrees from the equator.

equator or along a parallel of latitude, as we choose.

The daily rising and setting of the sun is only an apparent movement, produced by the rotation of the earth from west to east. An observer placed at Greenwich at noon will see the sun due south of that point. Twenty-four hours later, at noon on the following day, he will again see the sun in the same direction. This means that in 24 hours the earth, in making one rotation, has carried our observer through all the 360° of a full circle. 360° in 24 hours means 15° in one hour, and 1° in 4 minutes.



MERIDIANS OF LONGITUDE. Fig. 12. Showing the International Date Line running east of New Zealand and Fiji and west of the Aleutian Islands.

From this follows a very interesting result: an observer at a place X, 15° east of Greenwich, will see the sun in the south an hour earlier than our observer at Greenwich. In other words, when it is noon at Greenwich it will be already 1 p.m. at X. Similarly, at a place Y, 15° west of Greenwich, it will not be noon till it is already 1 p.m. at Greenwich.

This explains what is meant by the expressions Greenwich time and local time, and the figures given above will enable us to work out, for any given time at Greenwich, the local time of any place of which we know the longitude. In other words, difference of longitude tells us difference of time.

Fig. 12 is a map of the world on Mercator's projection (*see* Lesson 12, p. 392). Along the top are given the longitudes east and west of Greenwich at 15° intervals. Along the bottom you find local time at the various longitudes when it is noon at Greenwich.

Determining Longitude by Time. Difference of longitude tells difference of time; then obviously difference of time will tell difference of longitude. In other words, if an observer at any place is in a position to compare local time with Greenwich time, he can quite easily work out his longitude.

This comparison can be made by means of a clock or watch (chronometer) which keeps Greenwich time, or by means of a time signal, transmitted by cable or wireless, which tells our observer, to the fraction of a second, when it is noon, or any other time, at Greenwich. Longitude can also be determined by astronomical observations.

Our readers may remember how the hero of Jules Verne's thrilling romance 'Round the World in Eighty Days' nearly lost his bet because he forgot that, by travelling from west to east, he had gained a day. If he had travelled in the reverse direction he would have lost a day. The explanation is this:

Two travellers, A and B, start from Greenwich, in opposite directions, to travel round the globe. They meet on a small island in the Pacific, situated on the meridian of 180°, when, by Greenwich time, it is midnight between a Tuesday and a Wednesday. Local time, of course, is noon (180° = 12 hours), but traveller A, who has come from the west, will call it noon on Wednesday (12 hours in advance of Greenwich time), while traveller B, who arrived from the east, will be equally certain that it is noon on Tuesday (12 hours behind Greenwich).

In order that A may not gain a day (like Jules Verne's traveller) he must, on continuing his voyage, go back to noon on Tuesday, so that the 24 hours between Tuesday noon and Wednesday noon will appear twice over in his journal. Similarly, in order that B may not lose a day, he must go right on to noon of Wednesday, so that the period between Tuesday noon and Wednesday noon will not appear in his journal at all.

It should be added that the line (the International Date Line) at which the captain of a ship going round the world has to change the date in his log is not the same throughout as the meridian of 180°. It is deflected to avoid the inconvenience of two islands within a few miles of each other having different dates.

Local Times. If each town kept to local time, there would be fearful confusion in the railway time-tables, and travellers would always be too early or too late for their trains. To avoid this, local time is arranged by zones. Great Britain, Eire, Belgium, and France use Greenwich time as the basis of local time; while for Germany, Switzerland, Italy, and Hungary, basic local time is that of 15° east of Greenwich (noon at Greenwich = 1 p.m. in Berlin). In Canada and the United States there are five time-zones of 15° each, in which noon is respectively 4, 5, 6, 7, and 8 hours later than at Greenwich. Beginning with Great Britain in 1916, many countries have adopted 'daylight saving' measures by which local time is in advance of sun time during part or all of the year. Calculations to determine longitude must be based on true local time (i.e. sun time) and not on so-called 'summer time.'

LESSON THREE

What the Sun Does for the Earth

In the first Lesson of this Course we learned how the distribution over the earth's surface of the light and warmth we receive from the sun is affected by the fact that the axis round which the earth rotates is not vertical to the ecliptic, but is out of the perpendicular by an angle of 23½°. We illustrated this by means of diagrams showing the conditions at four points of the earth's path round the sun. Fig. 13 illustrates those conditions for approximately the 21st day of each month of the year. As in Figs. 7, 8, and 9, the parallel lines represent the sun's rays, while the arrowhead indicates the latitude at which the sun is overhead at noon.

The Seasons. We now find that the four positions shown in diagrams 7, 8, and 9 refer to the days in March and September when the sun at noon is overhead at the equator, and to the days in June and December when it is overhead at noon on the tropics of Cancer and Capricorn respectively. It appears, then, that the two tropics represent the farthest latitude from the equator at which the sun is ever overhead, so that, during the remaining eight months, the sun is overhead at latitudes lying between the two tropics. This area, to which, as to the two parallels which enclose it, the term tropics can be applied, is marked in the diagrams by a light stipple.

We now arrive at an explanation of the two words solstice and tropic. *Solstice*, from a Latin word signifying the standing still of the sun, is the time at which the sun, having reached the farthest point north or south of the equator at which it is ever overhead, appears to stand still before turning back towards the equator. This turning back explains the meaning of the word *tropic*, which is derived from the Greek word for to turn. The letters N and S in the diagrams refer to the north and south hemispheres respectively.

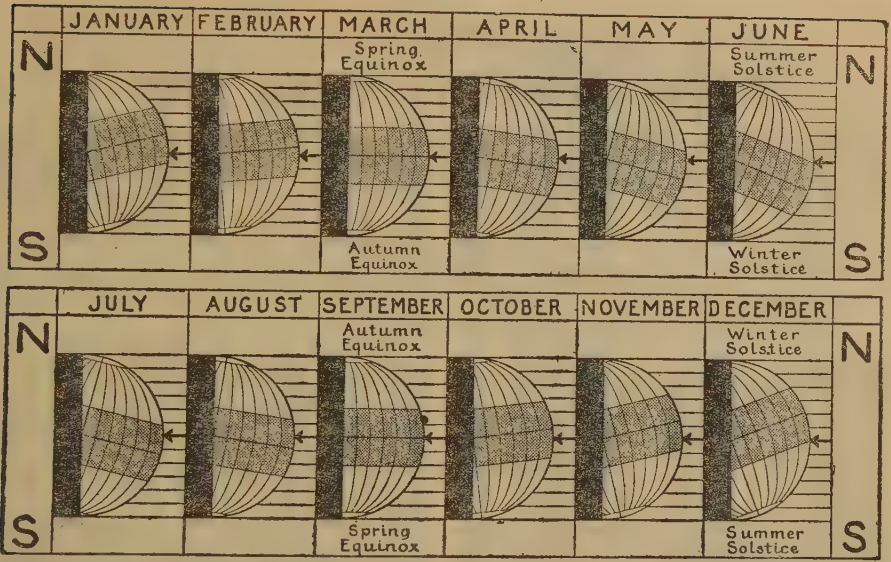
Two factors affect the amount of warmth reaching a given point on the earth's surface. The sun's rays lose heat during their passage through the atmosphere. The longer that passage, the more heat will they lose. Thus it is obvious that vertical rays, having the shortest distance to travel through the atmosphere, will bring most warmth.

Secondly, when a heat-bringing ray strikes a flat surface vertically it has a smaller area to warm than if it comes at an angle. Consequently, that portion of the earth's surface will receive most warmth where the sun is overhead, and the farther away an area is from that point the less will be the amount of warmth reaching it.

If, as our diagrams show, it is winter in the northern hemisphere when it is summer in the southern, and vice versa, the same reversal will obviously apply to the intermediate seasons of spring and autumn. This brings us to a consideration of the two days in the year on which the sun at noon is overhead at the equator, these days being styled respectively the spring and autumn equinox (= equal night).

For this purpose, however, we must first note that the actual movement round its axis of the earth (which we cannot see), produces an apparent movement of the sun, which we can observe and follow any day, namely, that of rising in the eastern heavens, passing across the sky, and setting in the western heavens.

The sun rises at or very near the east point of our horizon on the day of the equinox, when, on its apparent path round the earth, it has to traverse 180° in 12 hours.



***SUN AND THE SEASONS.** Fig. 13. The four seasons are determined by the latitude at which the sun is overhead at noon. In these diagrams the horizontal lines represent the sun's rays. The stippled areas lie between the tropics of Cancer and Capricorn, the farthest latitudes north and south of the equator at which the sun is ever overhead at noon, a position marked by the arrows.*

Omitting astronomical detail, we may say, then, that on the shortest day its path will be shorter, and on the longest day it will be longer. Within these limits the sun will rise at a different point each day, so that we again find the winter and summer solstices marked by an apparent standing still (solstice) and turning back (tropic).

Day and Night. The meridians in our pictures of the earth are drawn at intervals of 15°, so that, as we learnt in the preceding Lesson, the sun, in its passage over one of these intervals, will be giving one hour's daylight to the earth. Our diagrams, being flat, show only one half of the earth's illuminated surface. Such diagrams cannot, of course, be used for ascertaining the exact length of day or night on various dates, but they are sufficiently accurate to illustrate general principles.

By counting the number of 15° intervals shown as illuminated, doubling that number (to include those not visible in the diagram), and remembering that the counting must be done along the parallel of latitude at which the sun happens to be overhead at noon, the student will now, with no further help beyond the diagrams themselves, be able to find the explanation of the following phenomena:

1. Day and night on the equator are equal all the year round.
2. Day and night are equal all over the globe on two days only, spring and autumn equinox.
3. The summer solstice, both north and south, brings the longest day and shortest night.
4. The winter solstice, both north and south, brings the shortest day and longest night.
5. Twice a year day and night are equal within the polar circles, as they are all over the globe. But once a year there is a twenty-four-hour day, and once a year a twenty-four-hour night, within each polar circle.

LESSON FOUR

Distribution of Land and Water

In Lesson 3 we learnt how the actual movement of the earth produced an apparent movement of the sun, and how this resulted in distributing the sun's warmth over the surface of the globe in such a way as to enable us to divide the year into certain periods which we call the seasons. This would appear to show that the distribution of the sun's warmth depends wholly on latitude, the areas nearest to a latitude at which the sun was overhead receiving most warmth, while the farther away an area from that latitude the less warmth would it receive. Such, indeed, would be the case if the earth's surface were all land, or all sea, without differences of height and depth.

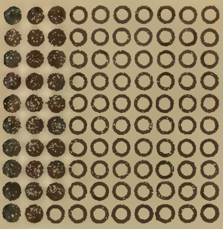


Fig. 14. Proportion of land and water shown by black and white disks respectively.

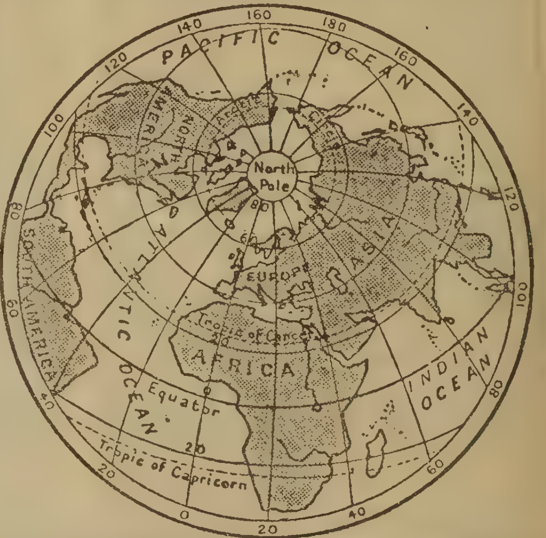
That in actual fact, however, the distribution of temperature over the globe is very considerably affected by circumstances other than latitude will be made clear by a single example. The Strait of Belle Isle, separating Newfoundland from the southern end of the Labrador coast, is in the latitude of London. This means that the British Isles are in the same latitude as the coast of Labrador, which is generally icebound for several months during the winter. This and other similar instances are due to two circumstances: the irregular distribution of land and sea over the globe, and differences in height of the land above sea level.

Consequently, before we proceed to the study of climate, in connexion with which we shall have to take into consideration not only temperature, but also such things as atmospheric pressure, winds, ocean currents, and rainfall, we must first get some idea of how land and water are distributed over the surface of the globe, and how highland and lowland are distributed over the land surface.

The total area of the globe has been calculated at 197,000,000 square miles, of which 29 per cent (57,000,000) is land, and the remaining 71 per cent (140,000,000) water, as illustrated by Fig. 14. That even this small amount of land is not in any way evenly distributed may be learnt from two maps showing the hemisphere which has most land and that which has most water (*see* Figs. 15A and 15B).

Land and Water Hemispheres. The land hemisphere contains Europe, North America, Africa, practically the whole of Asia, and most of South America, while in the water hemisphere are to be found only Australia, the eastern Archipelago, the Antarctic continent, and the narrow southern end of South America.

As regards latitude also, the distribution of land is very uneven, as illustrated by Fig. 16, which shows (in black) the area of land in each of the 18 ten-degree zones from pole to pole. By far the larger proportion of land (North America, Europe, Asia, and North Africa) lies north of the equator, while, to the south of that line, even Australia and the Antarctic continent do not suffice to



LAND HEMISPHERE. *Fig. 15A. All the continents except Australia are contained, or almost contained, in this hemisphere.*

rectify the adverse balance due to the narrowing, at their southern extremities, of South America and Africa. The vast extent of the southern ocean, especially between 40° and 60° south latitude, is shown.

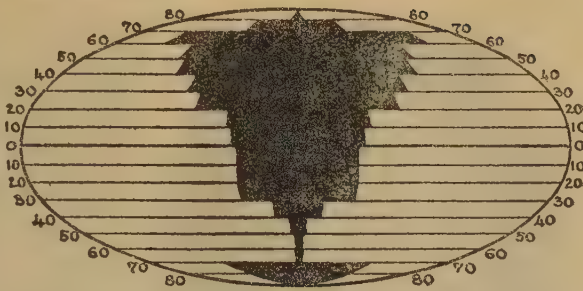


Fig. 16. Distribution of land from pole to pole; the great proportion of it lies north of the equator.

High Land and Deep Sea. No less striking are the irregularities which we find when we come to examine the relief of the earth's surface, and the distribution of high and low land, of deep and shallow sea.

In Fig. 17 (p. 374) the seven continents are represented by seven circles. In each of these the black centre shows the area more than 6,000 feet above sea level, while the white rim is land up to 600 feet above sea level. The dotted area, within which stand the seven continents, is sea less than 600 feet deep, and the broad, black rim surrounding the whole stands for sea more than 6,000 feet deep, amounting, in fact, to more than half the total surface of the earth. Thus Fig. 17 brings out clearly certain characteristic differences in the physical geography of the separate continents.

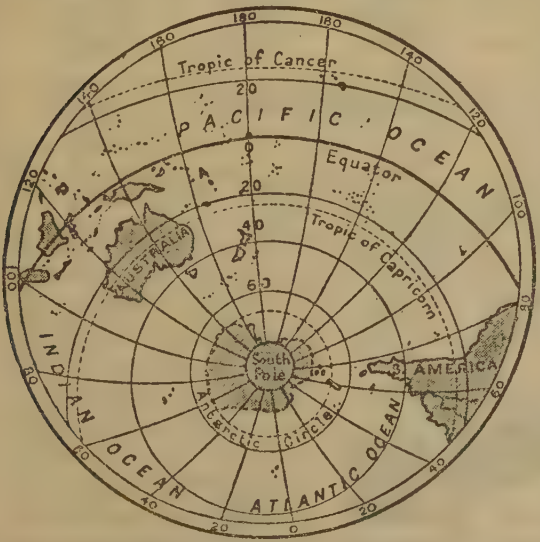
Fig. 18 (p. 374) gives what is called a *hypsographic curve*, showing the relative amount of land and water at various heights and depths. Starting from the greatest measured sea depth (31,500 feet in the western Pacific), the curve rises sharply to what is really the main floor of the ocean. As this floor rises to a depth of only 6,000 feet, its slope again becomes steeper (compare also Fig. 17). At the 600 feet line we reach the so-called continental shelf (dotted in Fig. 17), in the shallow waters of which are carried on most of the world's great fisheries, such as those in the North Sea and on the Newfoundland Banks.

Between sea level and 600 feet above it are to be found the great lowlands, on which live a very large proportion of the peoples of the world. Again, the slope steepens more and more as it reaches 6,000 feet above sea level, to culminate in Mount Everest (29,000 feet), the greatest height of land.

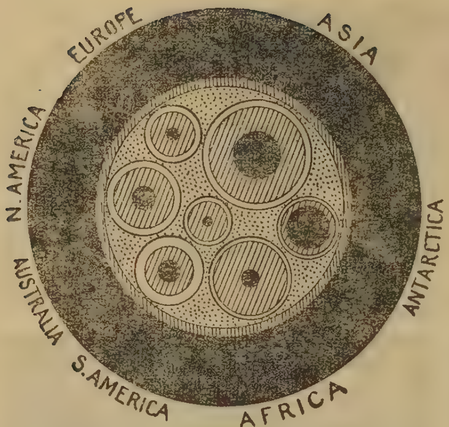
The six squares appearing on the right of Fig. 18 show the comparative area of land surface and sea floor at the various heights and depths referred to. The enormous extent of very deep sea is again strikingly illustrated in this diagram.

Continental Lowlands and Highlands. The diagrams in Fig. 19 (p. 374) repeat in a different way the information contained in Fig. 17, so far as it refers to the six continents. While taking no account of their relative sizes, it shows, for each continent, the proportion of land in each of the three belts of height above sea level: up to 600 feet (white), 600 to 6,000 feet (shaded), and above 6,000 feet (black).

Europe is the only continent of which more than half is lowland. This is accounted for by the great plain of north Germany and Russia. As this plain, especially in the west,



WATER HEMISPHERE. *Fig. 15B. This hemisphere comprises the greater proportion of the world's oceans.*



LAND AND WATER. Fig. 17. Seven continents are shown by circles: black over 6,000 ft.; shaded, between 6,000 and 600 ft.; white ring, under 600 ft. The dotted area indicates shallow seas; the shaded ring, water of medium depth; the broad black rim, deep seas.

is one of nature's great storehouses of mineral wealth, with easy communications in all directions, the fact that northern France, Belgium, and central Germany from west to east, together with part of the British Isles, form one of the world's most densely populated and most highly developed industrial regions, is sufficiently explained.

Asia has by far the largest proportion of the highest land (over 6,000 feet) in the shape of the great belt of upland extending from Asia Minor eastward through Persia (Iran) into Central Asia, where it includes Tibet and the Himalayas. Asia's proportion of lowland is small (only Africa has less) because a great part of the northern plain lies above the 600 feet line. This northern plain and the central tableland are sparsely peopled, but the dense population of the Ganges valley and of the river valleys and lowlands of eastern China helps to bring the population of India and China together to over three-quarters of Asia's 1,000 odd millions.

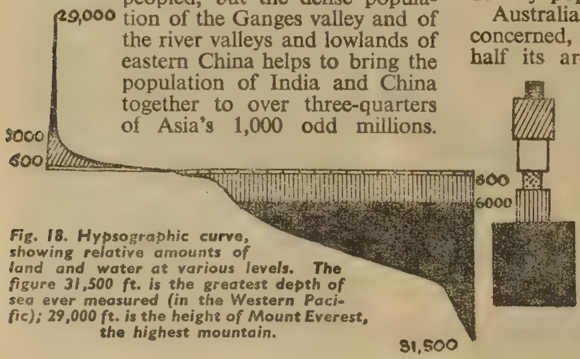
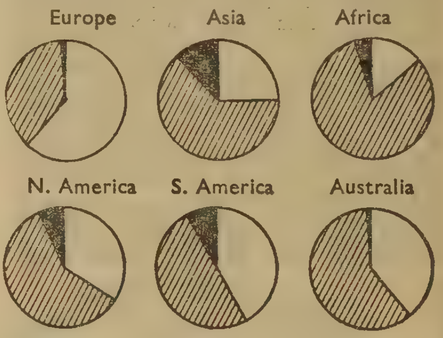


Fig. 18. Hypsographic curve, showing relative amounts of land and water at various levels. The figure 31,500 ft. is the greatest depth of sea ever measured (in the Western Pacific); 29,000 ft. is the height of Mount Everest, the highest mountain.

Africa is largely a plateau continent. Its percentage of lowland is barely one-quarter of that of Europe, while four-fifths of its area lie between 600 and 6,000 feet. African rivers, being mostly rivers of the plateau, descend sharply to the narrow coastal plain, so that their lower courses are much interrupted by rapids, often within only a few miles of the coast. Africa's very high land is of small extent. Only Europe and Australia have a smaller proportion.

North and South America do not differ much in the extent of their very high land, as to which they come next after Asia; but South America has the larger proportion of lowland (Amazon Basin, Argentina). North America's great plains, the prairies of Canada and the United States, lie almost entirely above the 600 feet line. Much of South America's very high land lies within the tropics, but its elevation has a moderating influence on the climate and makes this region, for its height above sea level, very densely populated.



HEIGHT OF LAND. Fig. 19. The six continents; up to 600 ft. is shown white; between 600 and 6,000 ft. shaded; over 6,000 ft. is marked in black.

Australia, is, so far as its western half is concerned, another plateau, with well over half its area between 600 and 6,000 feet. The great central lowland, however, keeps its proportion of land between these two down to about three-quarters of that of Africa. Australia's proportion of land over 6,000 feet is under one per cent. The highest summits are those of the Great Dividing Range, a vast mountain system in the south-east of the continent where Mount Kosciusko, in New South Wales, rises over 7,300 feet.

LESSON FIVE

The Chief Factors in Climate

The chief factors in climate are the variations, at different times of the year, and in different regions, of temperature, atmospheric pressure, winds and rainfall. By dealing with these four factors in the order given here, we shall be able to show how temperature affects the distribution of atmospheric pressure as recorded by the barometer. Pressure, again, affects the direction and strength of the prevailing winds, which in turn are directly responsible for the distribution of rainfall.

In Lesson 3 we learnt that the amount of warmth reaching a particular area of the earth's surface varies according to the latitude at which the sun is overhead at noon. Were the earth's surface all land or all sea, variations of warmth would therefore depend on latitude only. But this is not so. Land is heated more quickly than water, because it is heated at the surface only. Water is heated more slowly than land, because the warmth spreads through the whole mass. Therefore land reflects more heat, because it absorbs less; water reflects less heat, because it absorbs more. The result is that land cools fairly quickly and water cools fairly slowly.

It is well known that climbers, balloonists, and aircraft pilots often suffer severely from cold at high elevations. Thus it is evident that temperature is dependent, not only on latitude and irregular distribution of land and sea, but also on height above sea level.

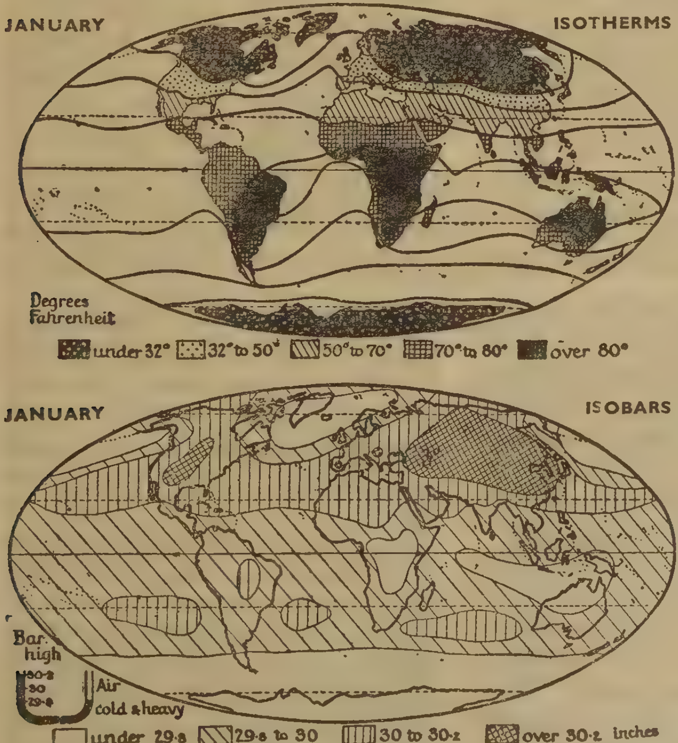


Fig. 20. Mean or average temperatures (isotherms), and distribution of atmospheric pressure (isobars) over the earth's surface during the month of January.

Isotherms. Temperature is generally expressed on a map by means of isotherms, i.e. lines of equal warmth, drawn so as to connect all points having one and the same temperature, the lines being more or less numerous according to the scale of the map. By means of isotherms, then, we can show the temperature in a given region at any particular time, or we can show the distribution over that region of the average temperature for a long or short period.

Before we draw the resulting isotherms on our map, it will be necessary to introduce a rather important modification in our temperature figures. If we took account of such differences of temperature as exist between the summits of the Himalayas and the plain of the Ganges, or between the great plateau within

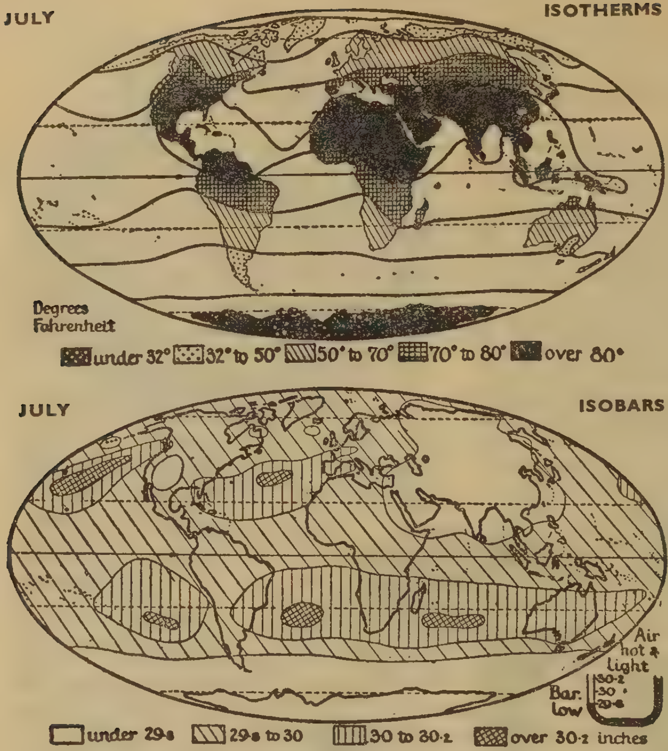


Fig. 21. Mean or average temperatures (isotherms) and distribution of atmospheric pressure (isobars) over the earth's surface during the month of July.

the Rocky Mountains and the prairies lying east of them, our map would be so crowded with detail as to be useless.

Observation has shown that, on an average, temperature decreases by 1° Fahrenheit for every 300 feet rise in elevation. If, therefore, to the temperature recorded by the thermometer at an elevated station we add 1° for every 300 feet of its height above sea level, we shall get the temperature recorded at the station converted, or, to use the technical term, reduced to sea level temperature.

These reduced temperatures are those we record on our maps, and on which we base our isotherms. The final result, then, takes the form of the two maps (top charts of Figs. 20 and 21), which show the mean, or average, temperature over the earth's surface during January and July.

Ocean Temperature Lines. If temperature were dependent on latitude alone, we should find the isotherms, the lines of equal temperature, running round the globe parallel to the equator. Our maps, however, give us a very different picture. In January (southern summer) and again in July (northern summer) the isotherms of 80° are closer together over the sea than over the land, which means that the hottest area is more extensive on land than at sea. For example, over the Pacific Ocean there is no area with an average temperature of over 80°, either north or south of the equator. Even mere nearness to the sea affects temperature in this way as is illustrated by the cooler strips running south along the west coasts of South America and South Africa during the southern summer, and running north along the west coasts of North Africa and North America during the northern summer.

Continental Isotherms. Indeed, North Africa, during its summer, provides a striking illustration of the conditions described above. This great land mass appears on our map as the most extensive area with this very high average temperature, while off its west coast the isotherms are so close together as almost to make the region of cooler air continuous from north to south over the Atlantic.

When we come to consider the areas with low temperature, we find the same thing. During the northern winter, nearly half North America and more than half the immense area of Asia have an average temperature of below 32° (freezing point). Between the two, however, under the moderating influence of the Atlantic Ocean, the isotherm of 32° is bent so far north that all north-western Europe, nearly to the Arctic circle, is included in the warmer area, with a mean temperature, for January, of over 32°. Note also how the isotherm of 32° turns sharply north along the coast of eastern Asia.

A comparison of the facts stated here gives us an illustration of what is meant by continental and oceanic climate respectively. Continental climate is characterized by extremes (hot summers, cold winters), because air over a land surface becomes hot or cold quickly. Oceanic climate, on the other hand, is more moderate, because air over the sea is warmed or cooled more slowly.

Isobars. The distribution of atmospheric pressure is shown on a map by means of isobars, i.e. lines of equal weight (of air). They are drawn so as to connect all points having equal atmospheric pressure—the lines, as in the case of the temperature maps, being more or less numerous according to the scale of the map.

The two lower charts in Figs. 20 and 21 show the average atmospheric pressure over the earth's surface (land and sea) for the months of January and July. Hot air is light and tends to rise, while cold air is heavy and presses downwards. As temperature is observed by means of the thermometer, so atmospheric pressure is recorded by the barometer, i.e. measurer of weight (of air). The small inset diagrams illustrate the effect of light and heavy air respectively on the barometer, and will serve to explain the meaning of the reference to inches appearing under the two maps.

LESSON SIX

Winds, Tides and Ocean Currents

The weight of the air and its pressure on the earth's surface vary within narrow limits. This pressure, as we learned in Lesson 5, is measured by the barometer, and under average conditions may be taken as equal to the pressure of a column of mercury just under 30 inches high.

Air over a surface heated by the sun is warmed quickly over the land, more slowly over the sea. When air is warmed it expands and rises, as does the air in a chimney when the fire is lighted. If it rises, it must be lighter than it was before. Hence it exerts less pressure, and as it cannot support as large a column of mercury as it formerly did, the barometer falls. As hot air is light, so cold air is heavy and tends to sink. It can support more mercury than it could before, and the barometer will rise.

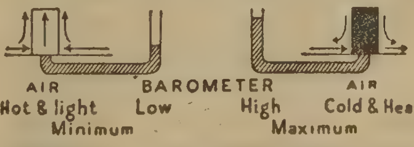
These are the phenomena which the two charts of atmospheric pressure (Figs. 20 and 21) show for the whole surface of the globe, in the shape of the averages for the months of January and July. By comparing the charts referring to the same month, we see how changes of temperature affect atmospheric pressure.

Atmospheric Pressure. In January (northern winter) the cold areas of North America and Asia are represented by two areas of heavy pressure, with areas of lighter pressure between them, because air over the sea keeps warm longer. In July (northern summer) the areas of light pressure are over the land, because air over the land becomes hot, and so light, more quickly than over the sea.

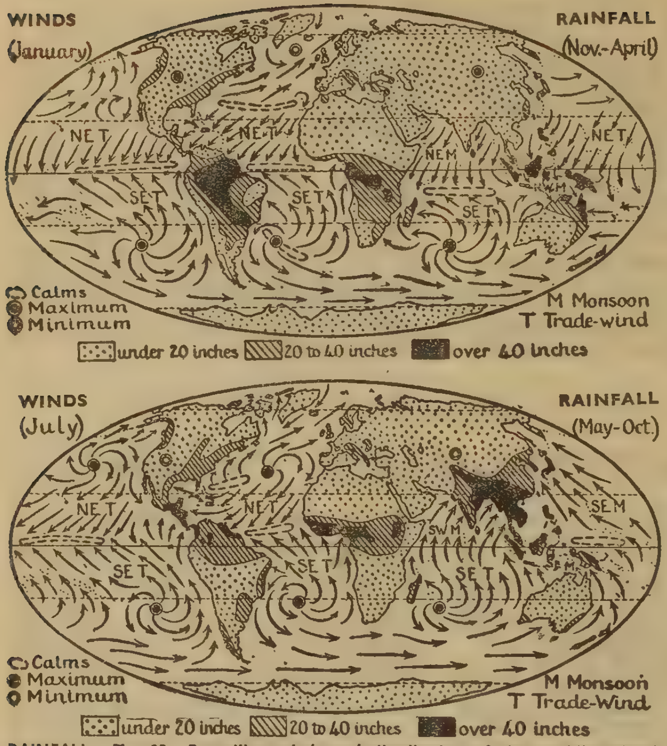
In the southern hemisphere, January (southern summer) shows very clearly how the heating of South America, South Africa, and northern Australia makes for light pressure over those regions, while the Pacific, Atlantic, and Indian Oceans have corresponding areas of heavier pressure. Conditions are not quite so clearly marked in the southern hemisphere during July (southern winter), as the land areas are comparatively small, and have not so strong an influence as the vast land mass of Asia.

Fig. 22, showing how a barometer works, should help to make clear the connexion between atmospheric pressure and the direction of the wind. If the air rises over a certain area, winds will blow inwards towards the centre of that area, to take the place of the air which has risen. Similarly, when the air over an area sinks, winds will blow outwards. For further information concerning the barometer the student is referred to Physics, Vol. I, page 336.

If temperature and, consequently, pressure were influenced by latitude only, there would be winds blowing constantly from north



BAROMETER. Fig. 22. Diagram showing the principles upon which a barometer works (see text above).



RAINFALL. *Fig. 23. Prevailing winds and distribution of the world's rainfall.*

and south towards the latitude at which the sun, being overhead at noon, warms the earth's surface most quickly and thoroughly.

The irregular distribution of land and sea affects the distribution of temperature, and consequently of pressure also. Finally, as we have now to learn, it influences the direction of the prevailing winds, shown, again for January and July, in Fig. 23.

High and Low Pressure. For the sake of clearness the chief centres of high pressure (maxima) and of low pressure (minima), from or to which the chief wind currents are directed, have been marked on these two maps. Winds do not, however, blow directly outwards or inwards from or to these points. The earth's rotation causes them to incline to the right in the northern hemisphere and to the left south of the equator. In other words, a north wind blowing towards the equator becomes a north-east wind, while a south wind blowing towards the equator becomes a south-east wind.

Origin of Winds. The above explanation should enable the student to trace the origin of the winds shown in our diagrams as blowing regularly from the north-east in the Pacific and Atlantic Oceans north of the equator, and from the south-east in all three oceans in the southern hemisphere. These are the trade winds, so called because in the days of sailing ships they were of paramount importance to traders on the great ocean routes. Over the vast expanse of the southern ocean which surrounds the Antarctic continent, the south-east trade winds become merged in the prevailing westerly winds, called, from their average latitude, the Roaring Forties.

In the northern Indian Ocean conditions are different, owing to the influence of the great land mass of inner Asia, which is very cold in winter and very hot in summer. In January winds come from the north-east, driven by the high pressure prevailing over a cold area, but in July they blow inwards to the region of hot, light air. These are the north-east and south-west monsoons respectively, features of India's climate. Similar phenomena occur in the western Pacific and along the west coast of Central America.

Rainfall. We can now learn how the direction of the prevailing winds affects the distribution of the world's rainfall, which our maps show, not for two single months,

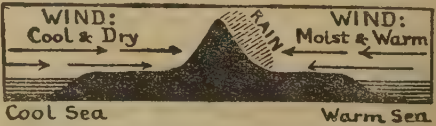
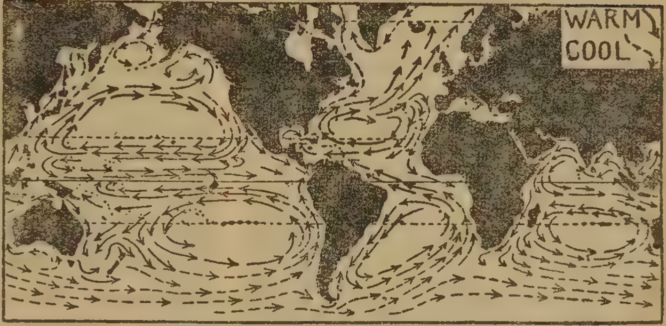


Fig. 24. Diagram showing why some winds bring rain and others dry, cold weather.

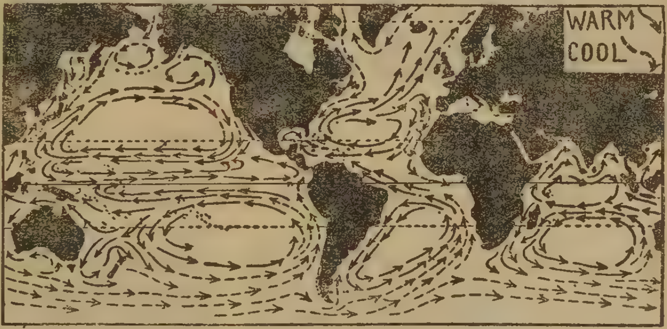
but for half the year in each case. A wind blowing inland over the sea (*see* Fig. 24), especially if that sea be warm, carries moisture, which it will deposit as rain when it strikes high ground. If it has passed over dry land it will be a dry wind and bring no rain.

The contrast is most marked in India itself. The north-east monsoon, coming from the cold, dry region of Central Asia, carries no moisture. The time when it is blowing is India's dry season. The south-west monsoon, on the other hand, has been blowing over the warm Indian Ocean and brings to the Western Ghats and to the southern slopes of the Himalayas in particular, as well as to south-eastern Asia generally, some of the heaviest rainfall to be found on the earth's surface.

SURFACE OCEAN CURRENTS (JANUARY)



SURFACE OCEAN CURRENTS (JULY)



OCEAN CURRENTS. *Fig. 25. Caused by wind, they are shown for winter and summer. The seasonal variation is noticeable chiefly in the Indian Ocean.*

The student should be able to find for himself other examples, as shown in the maps, notably the regions covered by the two great equatorial rain forests of South America and central Africa. The movement north and south of the areas of heaviest rainfall is due to the fact that the hottest area is north or south of the equator, to correspond with the northern and southern summers.

Movements of the Ocean. The ocean is in constant motion, in a number of ways. First of all, there is the movement of the tides, familiar to all who have spent any time by the seashore or near tidal rivers. Tides are closely associated with the phases of the moon. They are due principally to the attraction of the earth's waters by the mass of the moon, which has the effect of heaping up the waters of the ocean at the point on the earth's surface on the line connecting the centre of the earth with the centre of the moon. This point is constantly changing owing to the rotation of the earth on its axis, and if the earth were covered entirely by a film of water, the tide would sweep steadily round and round the world in harmony with this rotation. But the intervention of land masses stops and deflects the onward rush of the waters, and partly accounts for the differences in high and low tide at different places on what would be the line of the tide's sweep if it were uninterrupted.

Another factor causing tidal variations is the attraction of the sun's mass for the earth's waters, which is similar to that of the moon, but less powerful. When the point of the sun's attraction differs from that of the moon, it has a counteracting effect, and we get tides of reduced volume, known as neap tides; but when the two points approximate to one another, as they do at the time of full and new moon, their effect produces the specially high tides known as spring tides.

Ocean Currents. A phenomenon of great importance to climate, and, in the days of sailing ships, to mariners, is illustrated in

Fig. 25, namely surface ocean currents. These are caused by the wind which, acting on the surface of the sea, not only causes ripples and waves, but also, if continuous, sets up regular currents, shown in the diagrams in simplified form.

As will be seen, most of the surface ocean currents flow steadily all the year in the same direction—the direction of the prevailing winds. The warm Gulf Stream, to which Great Britain and north-western Europe owe their much milder climate than that of other countries situated in similar latitudes, flows steadily from the Gulf of Mexico in a north-easterly direction across the Atlantic. The Labrador current, which is largely responsible for the long, bitter winters of eastern Canada, flows steadily southward between Greenland and the east coast of north America. In the northern Indian Ocean, we can see particularly clearly the effect of the prevailing winds in setting up surface currents, for the north-west and north-east monsoon drift of January changes, with the changing wind, to the south-west and south-east monsoon drift of July.

But these surface currents affect the ocean to a very small depth only. Below the surface are other currents, and about these and their causes much yet remains to be discovered. The relative salinity and density of the water, and its varying warmth in different areas, certainly help to determine the direction of these deep water currents. Salter, heavier water endeavours to flow beneath lighter, less salt water—one interesting result of which is that the very salt waters of the Gulf Stream, after they have been cooled as they move past Norway, are found at the bottom of the sea below the less salt waters of the Arctic ocean. In general, the deep sea currents are cold currents flowing from the waters of the Arctic and Antarctic towards the equator.

LESSON SEVEN

How Landscape Features Originated

This Lesson is devoted to a consideration of the more important of those surface features of the land, such as mountains, rivers, lakes, and glaciers, which not only give us what we call landscape, but which play such an important part in influencing the distribution and mode of life of the human race.

The stratified rocks, which cover so much of the earth's surface, were originally deposited horizontally (Fig. 26), in the form of mud, the product of erosion, carried into lakes and the sea by rivers, and falling to the bottom in the still water. In the Grand Cañon of the Colorado river the strata are plainly to be seen in their original horizontal position, being easily distinguishable by their various colouring.

Evidence of the changes of level by which such tracts have now become dry land is of various kinds. Fossil remains of sea or lake animals and vegetation are found at quite considerable heights above present-day sea or lake level; while such a formation as the Roads of Glenroy, near Ben Nevis, probably marks three successive positions of the shore of a lake.

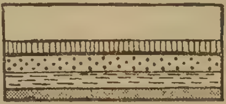


Fig. 26. Horizontal Strata.

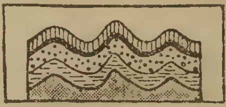


Fig. 27. Folded Strata.

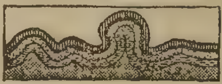


Fig. 28. Fan-like Folding.

These changes of level, however, can be only very slow and gradual, and would not have produced the much diversified landscape which the earth possesses today. There would have been no mountains. These features are due to movements of a more violent nature and are classified in four types: folded mountains, block mountains, highlands of erosion, and volcanoes.

Mountain Formations. A characteristic example of folded formation is that of the Jura mountains, along the Franco-Swiss frontier. The horizontal strata of which they consist now cover a much smaller area than formerly, with the obvious result that they have been thrown into the shape of waves or folds by pressure in a horizontal direction. From time to time the earth's crust has been thus affected and more or less regular ridges have been formed (Fig. 27). If the force and extent of compression are very great, we may have an almost fanlike shape (Fig. 28), a well-known example of which is on the shores of lake Titicaca in South America. Most of the earth's greatest mountain systems—examples springing to the mind are those of the Himalayas, Alps, Carpathians, and the American Rockies—were created in this way, although other agencies, especially erosion by water or ice, have been at work, to shape their details and give them their present outline.

The term block mountains is usually applied to a range which has been raised above the general level, or left standing as isolated blocks by the sinking of the surrounding country. A striking example is seen in the Harz mountains, which not only overlook the great plain of northern Germany, but are flanked by low-lying districts of smaller extent. The earth movements which bring about such formations often work violently in a vertical direction and are known as 'faults.' A mass of sedimentary rock, deprived of its foundations by the collapse of some great subterranean hollow, sinks down, leaving one or more blocks of strata in their original position (Fig. 29). The great rift valley of East Africa has a similar origin, while another example is the Rhine valley between Bâle and Mainz (Fig. 30). The geological formation of the highlands (the Vosges and Black Forest) for nearly 200 miles shows that the strata were once continuous, though now separated by a valley nearly 20 miles wide.

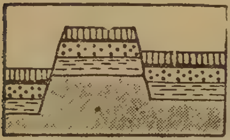


Fig. 29. Block Mountain.

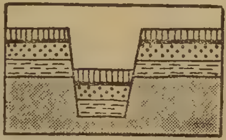


Fig. 30. Rift Valley.

Folded mountains may be worn down into rugged peaks and ridges by the action of water or ice. This action, when applied to undisturbed sedimentary rocks, will not perhaps produce such fantastic shapes as that of the Matterhorn, but in some parts of the globe the details of the surface features are due entirely to their glacial covering. The English Lake District has been carved out of a block of sedimentary rock by the action of water and ice, which removed the softer materials, so that the shape of the mountains is only partly due to their original structure. Norway is just such another block of which the fjords—and the narrow valleys continuing them inland—owe their existence and shape to erosion. An example of an isolated block is Table Mountain, Cape of Good Hope, which is 3,582 feet high.

Rivers. A bucket of water emptied on the side of a hill will take the shortest way it can find to the bottom. If the soil is soft, it will absorb all or part of the water. If it consists of hard rocks, the water will run over them, still taking the shortest possible way. The inequalities we may expect to find on any hill will not only give to the water a course winding from side to side to avoid obstacles, but may also change its gradient, as the slope varies.

In fact, the water from the bucket will exhibit, on a small scale, the phenomena that are observable in a mountain brook or a great river. It will run smoothly over ground of a regular slope; it will form bends to avoid stones lying in its path; a steep ledge will produce a waterfall; and should it find its way into a hollow capable of holding water, it will form a pool, just in the same way as the river forms a lake. The river, however, will not only take the shortest and easiest way it can find, but will also be continually at work trying to make that way shorter and easier still. It does this by means of erosion and deposition.

Mechanics of Erosion. Erosion signifies the wearing away of the banks of a river (lateral erosion), or the deepening of its bed (vertical erosion). Erosion is mainly of a mechanical character, but if the nature of the rocks is suitable to such a process, they may actually be chemically dissolved, as is the case with such materials as limestone or salt. Whether mechanical or chemical in form, whether working laterally or vertically, however, erosion tends to make the stream's course easier and more direct; and just as rough fragments are worn down by the sea waves to the rounded pebbles of our shingle beaches, so fragments of rock, large and small, rolled along by a stream not only become smooth and round themselves, but also help to wear away and smooth the ground over which the stream takes its course.

The amount of material which a river can carry along with it obviously depends both on the volume of water and on the speed of its flow. The carrying power increases as the sixth power of the velocity; this means that if the rate of flow is doubled, the carrying power will be multiplied by 64, so that a stream able to carry a pebble weighing an ounce will, if its speed be doubled, be able to shift a stone weighing four pounds. When a mountain stream reaches level country it begins to drop the débris brought from the upper reaches, owing to the reduction in speed of its flow.

While the wearing away of the banks tends to straighten a river's course, the wearing down of the bed, also effected with the help of débris carried along, will gradually even out the channel and give it a uniform slope. The extent to which a river will be able to perform this grading must depend largely on the varying hardness of the rocks over which it passes. It is not to be expected, therefore, that we shall find any river with a perfectly uniform gradient from source to mouth. Moreover, particularly hard rocks may resist erosive action so successfully as to remain in the shape of small rocky islands or reefs in the river bed. A well-known example of this is the Iron Gates through which the Danube passes from the plain of Hungary to the lowland region of its lower course. A river which approaches a uniform gradient is said to be 'well graded.' If a river had a perfectly straight course, deposition of its débris would take place with perfect regularity throughout; the larger fragments would be dropped first, then the smaller ones, while the sand and mud would be carried down to the mouth and even out to sea. A river with a winding course will have its swiftest current not always in the middle (as would happen with a straight course), but on one side or the other. The current being swifter on the outside of a bend, that part of a river will be able to carry the sediment away, thus keeping its bed clear and its channel deep. On the inside of the bend, in the more sluggish water, deposits of sediment collect.

When a river overflows its banks and floods the surrounding country, the sediment which it has brought down from its upper reaches will be dropped by the comparatively sluggish water of the flooded area outside the regular course. It is in this way that the Nile every year performs its work of fertilization, by spreading over the surface of the land the rich volcanic mud brought down from Abyssinia. When a river finally reaches a lowland plain it will be flowing too slowly to carry any but quite small particles of erosive products. The dredging operations necessary in the lower reaches of such rivers as the Rhine, Elbe, Rhône, and many others, are evidence of this. But the most striking result of sediment reaching the mouth of a river manifests itself in the formation of deltas, like those of the Ganges and the Nile.

Lake Formation. Heavy rainfall or the sudden melting of snow in an upland area may so increase the volume of water in a river that, in its course through level country, it overflows its banks. When the water has had time to drain away the river will return to its normal size and course. Under certain conditions this overflow might have been prevented from draining away. The temporary flooding would then have become permanent, and we should call it a lake. The large and small lakes dotted over the earth's surface owe their existence to a variety of causes, and we may distinguish three geological phenomena which have brought into existence hollows capable of holding water. These causes are erosion, deposition, and movements of the earth's crust, but lakes owing their origin exclusively to one of the three are comparatively rare.

A lake formed by erosion may generally be recognized by the fact that it is completely surrounded by rather hard rock. When a river passes over a bed of soft rock, this will be eroded more quickly, forming a hollow which must be filled before the river can proceed on its course.

Erosion by a river may, as we have learnt, take the form of actual chemical solution, and this occurs not only at the surface, but also by means of underground streams, which easily dissolve such material as limestone and salt. Underground hollows are formed, which ultimately collapse and, when filled with water, become lakes. Of this nature are the 'polyes' of the Dalmatian limestone, of which the lake of Scutari is an example, and probably also the meres of the Cheshire salt area. Often, however, it is only the deeper portion of a lake basin which has been formed in this way, and we shall generally find that deposition has contributed to the formation of the lake as we see it today.

Deposition most frequently takes the form of building a dam of sediment across a valley or at its mouth, which may either form a new lake or increase the extent and depth of an already existing rock-basin. In addition to the sediment carried by the streams, there is the débris brought down, in the form of moraines, by a glacier and deposited at its foot. Most of the Alpine lakes have been formed by glacier débris.

Lagoons and Broads. Lakes formed by deposition in lowland areas frequently take the shape of lagoons, cut off from the sea by river deposits, or by the products of sea erosion, transported by current and tide. Of this character are the lagoons of the Adriatic coast between Ravenna and Trieste, the 'haffs' of eastern Prussia, and the lagoons of the Camargue, at the mouth of the Rhône. The Norfolk Broads, though now mostly at some distance from the sea, were formed in this way, and some of them are still within reach of the tide.

Deposition may take the more violent form of a landslide extending right across a valley and so building up a dam; thus was formed Lake Gohna in Kashmir. A view of the eastern side of Wastwater, in Cumberland, shows clearly how the screes of Scafell, which may be described as a permanent landslide, have altered the original shape of the lake.

Lakes in the volcanic areas frequently take the form of crater-lakes, as in the Eifel district of the Rhineland, where the lake of Laach is an example. Lake Avernus near Naples was created in this way. The small gulf of Baiae, in the same district, was probably a crater-lake till its wall collapsed.

The animal kingdom also plays a part in this work. The lagoon of a coral island owes its existence to the reefs built up by the coral polyp. Another lake-forming animal is the beaver, with its dam-building habits.

In page 381 we referred to rift valleys, formed by the sinking of blocks of sedimentary rock. In the lower portions of such valleys water will naturally accumulate to form lakes. The best-known example is the Jordan valley, the lowest portion of which is filled by the Dead Sea. Lake Baikal in Siberia is another instance of a lake formed by a geological fault, as are also Lakes Nyasa and Tanganyika.

Very often the strata have been tilted to form the furrow in which the waters of the lake have collected, as in the case of Lake Titicaca in South America. The great lakes of North America were probably formed (at least partly) in this way, though here we find, in old shore-lines (once horizontal, but now tilted), evidence of earth movements since the lakes originally formed.

Changes of level over large areas may also lead to the formation of lakes. The Caspian and the Sea of Aral, now inland drainage areas, were once part of the sea, since cut off by a rising of the land. The whole of the shores of the Caspian, as well as part of the bottom of the Aral Sea, lie below the general ocean level. For the changes in the earth's surface through the ages, *see* Geology, in this Volume.

LESSON EIGHT

Volcanoes of Today and Yesterday

A FAVOURITE theory as to the immediate cause of volcanic action is that cracks in the earth's crust admit the sea to the earth's intensely hot interior, the explosion being brought about by the sudden formation of vast quantities of steam. This theory, however, leaves two things unexplained. First, there are some volcanoes at a considerable distance from the sea, such as Mt. Teleki and Mt. Kirungo, near Lake Rudolf in East Africa, and Koh-i-Tafdan in eastern Persia (Iran). Secondly, there are considerable stretches of coast without volcanoes.

This theory is, therefore, now generally regarded as erroneous, and the immediate cause of a volcanic outburst is sought rather in such occurrences as the development of gas or steam, due to the cooling of molten rock, or even to the purely mechanical pressure exercised by the collapse of some great subterranean hollow filled with molten matter. The simplest way of defining a volcano is to describe it as a hole in the earth's surface through which masses of molten matter are thrown up. But there is considerable variety in the phenomena which accompany the eruption.

Volcanoes of the type of Mt. Vesuvius seem to follow a regular programme, beginning, fortunately, with warning earthquakes. The liberation of gas and steam is then followed by the throwing up of ashes, accompanied by rain and even thunderstorms, and concluding with a generally quiet and steady outpouring of lava.

Vesuvius was believed to be extinct till A.D. 79, when the eruption in which Pliny the Elder lost his life overwhelmed Herculaneum with mud and Pompeii with ashes. The eruption of 1631 was even more terrible than that of 79, and destroyed two towns with most of their inhabitants. Since then the character of the mountain's activities has changed. Eruptions have been more frequent, but individually less alarming.

Mount Etna, the loftiest of Europe's volcanoes, came into existence as an island volcano close to the east coast of Sicily. By filling up the narrow strait with the débris of successive eruptions it ultimately joined itself to the main island. Of eighty recorded eruptions, that of 1669 was the worst, especially in the matter of the outpouring of lava. Vesuvius has one main crater, with a few subsidiary outlets scattered over its extensive surface. In the case of Etna, the actual main crater has fallen in on one side, forming a gorge with steep sides, the Val di Bove, and eruptions now take place through small scattered craters, of which there are nearly 200. Etna's most recent destructive eruption was in 1928.

The eruptions of Krakatoa, between Java and Sumatra (1883), of Mt. Tarawera in New Zealand (1886), and of Bandaisan in Japan (1888) were quite different from those described. They were really explosions—in the true sense of the word—of subterranean accumulations of gas and steam, which at Krakatoa and Bandaisan blew away a large part of the mountains in which they occurred, and then threw up vast quantities of rock fragments and ashes, but no lava.

Lava eruptions, pure and simple, are comparatively rare. The best-known examples are the Hawaiian volcanoes. A characteristic Hawaiian eruption takes place without anything in the nature of an explosion. An enormous mass of lava, in a very liquid state, simply rises until it overflows the crater's edge, obliterating everything that lies in its path.

A quite different phenomenon was witnessed at the eruption of Mt. Pelée, in the island of Martinique, French West Indies (1902), which ended, not with an outflow of lava, but with what can only be described as an avalanche in the shape of a cloud of water-vapour laden with glowing ashes, which rolled down the side of the mountain and destroyed the town of St. Pierre.

A recent volcano, Paricutin, in central Mexico, appeared as a plume of smoke in a cornfield in February 1943, but in twelve months had reached a height of 1,500 feet.

Extinct Volcanoes. When we speak of a volcano being extinct or dormant, we do not mean that volcanic activity has ceased altogether. It may manifest itself in various ways, though not so violently as in an actual eruption. Instances of this kind are the so-called solfataras, from which issue clouds of steam laden with sulphurous gases, as in the case of La Soufrière, in the island of St. Vincent, British West Indies, which erupted in 1902 and devastated nearly half the island. The geysers of the Yellowstone National Park, U.S.A., and of Iceland belong to this class of volcanic activity.

Perhaps the most interesting example of what we may call expiring volcanic action is to be found in the Rotorua district of New Zealand (North Island), where these phenomena may be studied in all their various forms of solfataras, geysers, fumaroles or smoke geysers, hot springs and lakes, and mud volcanoes. The wonderful pink and white terraces of Lake Rotomohana were destroyed by the eruption of Tarawera.

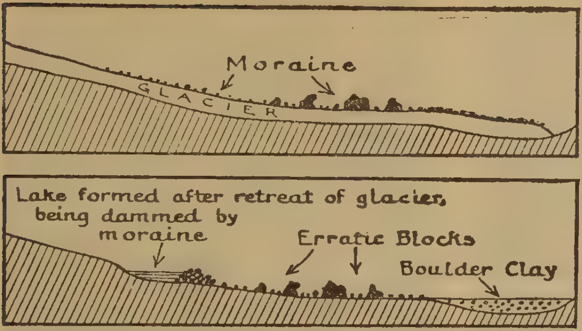
A very interesting form sometimes taken by an extinct volcano is that of a crater-lake. Lake Taupo in New Zealand is an example, and others are to be found in the United States (such as Lake Mazama in Oregon), in the Auvergne, central France, and in the Eifel district of Germany.

LESSON NINE

Glaciers, Ice-Fields and Icebergs

A MAP of the earth's ice covering (past and present), unless on a fairly large scale, could not show the distinction between the several Ice Ages of which we have evidence in various parts of the world; it would probably display merely the extreme limits to which at any time the two great present-day ice-caps (Arctic and Antarctic) extended respectively south and north towards the equator, and the extent to which some ice-fields in other parts of the world exceeded their present dimensions. The general climatic changes which caused these successive advances and retreats of the ice covering were so widespread that not only the Alps, the Caucasus, and the mountains of Central Asia, but even Mts. Ruwenzori, Kenya and Kilima-Njaro in equatorial Africa, as well as the southern Andes, all pushed their glaciers down to levels which today they are unable to reach. In South Africa and south-eastern Australia, too, we find evidence of former glaciation. For a fuller account of the Ice Ages *see* Geology in this Vol., pages 129–133.

Prehistoric Glaciation. Evidence of this appears in several forms. For instance, rocks have been scratched or polished by the passing over them of long-vanished glaciers; small fragments of rock, as in the so-called boulder clay, have been transported by glaciers, deposited when these retreated, and finally covered up by later sedimentary deposits; larger fragments,


Moraine
GLACIER
Lake formed after retreat of glacier, being dammed by moraine
Erratic Blocks
Boulder Clay

GLACIAL ACTION. Fig. 31. Above, sectional drawing showing a portion of the earth's surface covered by a glacier in the Ice Age. Below, the same portion today, the glacier having long since disappeared.

when transported in this way and left stranded, are called erratic blocks (Fig. 31).

Pot-holes are formed by fragments of rock under a glacier to which the glacier, by its movement, imparts a rotary motion. This not only rounds and polishes the fragment itself, but also hollows out a circular hole in the valley-floor.

Ice-fields and Glaciers. The two great ice-fields of today are Greenland (825,000 square miles) and the Antarctic continent (5,000,000 square miles). About 85 per cent of Greenland's area is covered by an ice-cap of unknown thickness, formed by pressure of the overlying snow turning the lower layers into ice. This pressure has the further effect of setting up in the whole mass a downward and outward movement which manifests itself in enormous glaciers, such as the 60-miles-wide Humboldt Glacier. The largest European ice-field is the Jostedalsbrae, in Norway, from which several glaciers descend to within 200 feet of sea-level—a lower level than is reached by any glacier not actually within one or other of the Polar circles.

The névé (snow-field) feeds the glacier, and is drained by it, just as a lake or swamp is drained by a river. When a glacier has to descend more steeply over a ledge of rock, the ice is broken up by crevasses and forms an ice-fall or a sérac (a pointed mass or pinnacle of ice). As it moves down the valley, a glacier will collect on its surface débris that falls from the steep slopes on either side. These fragments form the moraines, called lateral or medial according as they are at the sides or in the middle of the glacier. Further débris is transported by the friction of the glacier along the valley-bottom, the whole being deposited at the foot of the glacier as an end-moraine from which issues the glacier stream formed by the melting of the glacier ice.

The rate of movement of glaciers varies considerably. In the Alps it ranges from 50 to 200 feet a year. Movement is quickest at the surface and in the middle, being retarded by friction at the sides and along the bottom.

Origin of Icebergs. There are two ways in which Arctic icebergs are formed. A glacier, on reaching the sea, pushes on under water till the end of the glacier, buoyed up by the water, breaks off and rises to the surface as an iceberg. Glaciers reaching a precipitous coast push their ends over the edge till they break off and fall into the sea. As might be expected from the rather violent manner of their formation, the icebergs of the northern Atlantic, most of which come from Greenland, are often fantastic in shape. This is not so marked a feature in those of the southern ocean, because there the icebergs originate differently. Having a much smaller snowfall than the Arctic, the Antarctic continent has fewer glaciers. But the Great Ice Barrier, by which Captain Cook (1773) and Sir James Ross (1841) found their way south effectually barred, is a formation peculiar to the Antarctic. It is the breaking up of this barrier, or shelf-ice as it is called, which originates the southern icebergs, most of which are not so high as those of the north, though often greatly exceeding them in surface area.

Drift-Ice. This term includes not only icebergs, but also the floes into which the Arctic pack-ice and the Antarctic shelf-ice break up on the approach of summer. Its distribution is strongly influenced by the prevailing ocean currents. The effect of the Gulf Stream in preventing the drift-ice from reaching the British Isles is very marked, while the cold Baffin Bay current often carries it as far south along the Atlantic coast of North America as Cape Hatteras, in the latitude of Gibraltar. In the southern ocean the prevailing westerly winds prevent the drift-ice from travelling any great distance north (*see* Figs. 23 and 25, pages 378 and 379, for winds and currents).

Owing to the continual play of the currents the Arctic Ocean (except in the extreme north) is never completely frozen over, its ice covering consisting rather of cakes of ice (floes) which become smaller and less numerous as the summer advances.

The distribution of sea-ice in the northern portion of the Atlantic and Pacific is largely influenced by the prevailing westerly winds in those areas, with the result that the western coasts of North America and Eurasia are generally warmer than their eastern coasts. Thus the rivers and harbours of northern China, in the latitude of the Mediterranean, are largely ice-bound in winter, as is also the Gulf of St. Lawrence, which lies in the latitude of the English Channel.

The freezing over of certain seas is of importance in connexion with world trade; it causes those necessary seasonal changes which are made in some of the great steamer routes. When Quebec becomes inaccessible by the freezing of the Gulf of St. Lawrence, Halifax, which is ice-free, takes its place as Canada's chief port of entry. The line connecting Port Churchill, on Hudson Bay, with the Saskatchewan railways, for the direct export of the prairie wheat is, of course, useless in winter.

Lakes generally freeze from the surface—therefore much more slowly when exposed to wind. Of the great North American lakes, Lake Erie, the most southerly, freezes along the shore only; the others, usually all over.

Rivers mostly freeze from below (ground-ice which rises to the surface). In western Europe rivers do not habitually freeze in winter, though they may frequently become blocked by accumulations of ice brought down from their upper reaches.

Snow does not play such an important part in physical geography as ice. For statistical purposes, it is usual to reckon a foot of snow as equal to an inch of rain. The length of time during which snow lies on the ground varies with latitude and elevation above sea-level, till the lower limit of permanent snow, the snow-line, is reached. The height of this line varies from sea-level in most parts of the polar regions to about 15,000 feet in the Himalayas and the tropical parts of South America and Africa. As regards Europe, the snow-line is at nearly 9,000 feet in the Pyrenees, about 7,000 feet in the Alps, and 3,000 feet in Norway.

LESSON TEN

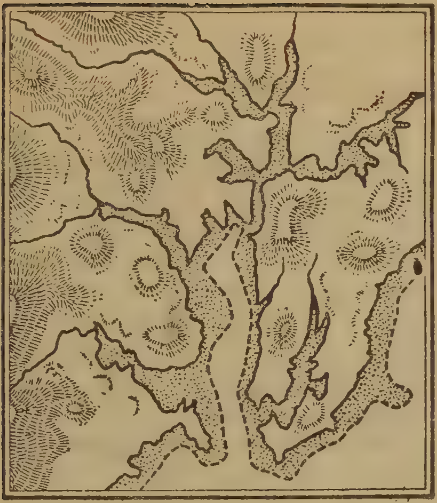
The Shaping of Shore Lines

We shall not expect a continent with so simple and uniform a table-land formation as that of Africa to have a very complicated outline. In western Europe, on the other hand, the long, much-indented shore line seems to be the natural result of a varied land-surface formation. The nature of the land along the coast will, however, be responsible for the main features only. For the working out of the details, we must look to two other factors: movements of the earth's crust and the action of the sea.

The effect on the shape of a shore line of the rising or sinking of the land is best illustrated by means of the sketch-map of a port on a rocky coast (*see* Fig. 32). At high tide—which is the same as saying that the land has sunk—there will be quite a complicated outline of coast, with deep indentations. At low tide, when the land has risen, a level stretch of sand will be exposed, and the outline will be much simpler.

Drowned Valleys. Bays formed by the sinking of land may be best described as 'drowned valleys,' and their shape will vary with the nature of the land along the coast. Thus Sydney harbour, Australia, reproduces in its outline the shape of a valley which descends from the east-coast range at right angles to the coast. Another type of drowned valley is San Francisco harbour. Its entrance, known as the Golden Gate, represents a transverse valley through which the sea has gained admittance to form, in the low-lying region behind the coast range, the actual bay. Where there are two or more parallel coast ranges, with transverse valleys, we get such coasts as those of southern Chile and British Columbia, where the sea has got in behind the outer range. This latter is now represented by strings of rocky islets, and the drowned valley by a narrow strait separating them from the real coast-line, now formed by what was the inner range.

A well-known form of drowned valley is to be found where glaciers have been at work. Here the result will be a long, narrow, steep-sided bay, which we call a fjord. It is generally shallow at its mouth, which is distinct evidence of its glacial origin, being due to the presence of a submerged end-moraine. The most remarkable instances of fjords are to be found in Norway, other



SHORELINES. *Fig. 32. Sketch-map of a coastal port showing the shore lines at high and low tides.*

examples being the sea-lochs of western Scotland, as well as the narrow inlets of Labrador, Greenland, and the South Island of New Zealand.

Although not producing such striking coastal formations as those referred to, similar processes occur on low-lying coasts. The lagoons (limans) of the Russian Black Sea coast, although the rivers are gradually filling them with alluvial deposit, corresponded strictly, in their original shape, with the contours of the land. The estuaries of the Orwell and Stour are also good examples.

Where parallel mountain ranges run at right angles to the coast, we find them reproduced in the shape of long, narrow peninsulas, with narrow bays between them, as in Dingle Bay, Valentia Harbour, and elsewhere in south-western Ireland. This 'ria' formation, as it is called, takes its name from the similar type to be found in north-western Spain, where Vigo Bay and Corunna harbour are good examples.

The sinking of a low-lying sandy shore lined with sand dunes will result in the formation of shallow coastal lagoons, as in the Landes of south-western France. The valuable Bulgarian salt lagoons were probably formed in this way.

Where the land has risen the sea-floor will be exposed. If level, it will form a coastal plain with a very simple shore line. The southern shore of Hudson Bay is a good example of this, as is also the Atlantic shore, south of New York.

Coast Erosion. The action of the sea on the land along the shore line is of a twofold nature, destroying or building up. Coast erosion may take the form of a steep cliff-face being undermined by the sea, with the fallen fragments along its base, and sandy beach above low-water mark. Examples of this may be found at several places along the south coast of England, with its soft chalk cliffs. One of the most striking instances of erosion by the sea is Heligoland, which in A.D. 800 had a coastline of 120 miles, reduced by 1900 to only 3 miles.

Low-lying coasts are often exposed to destructive sea erosion of a rather different nature. Storms which, in the case of a rocky coast, merely increase the eroding action of waves, become simply catastrophic when striking low-lying, and therefore defenceless, coasts or islands. Within historic times the Zuider Zee in Holland was a comparatively small inland lake many miles from the sea, while the East Frisian Islands were either not islands at all, or were close to the coast, and much larger than they are today.

Destroying at one place, the sea may be building up elsewhere, and in this latter work the play of the prevailing currents, or of the tide, takes a considerable part. Familiar examples are Chesil Beach, Dorsetshire, which now joins the Isle of Portland to the mainland, and the silting up of the Cinque Ports of Romney, Rye, Winchelsea, and Hythe.

It is quite permissible to speak of several ages in the life of a shore line. In its childhood, a coast presents itself as formed under conditions due to the shape and undulations of the adjoining land. In youth and middle age, we find it with a varied and often broken outline, due to unequal erosion of rocks of varying hardness. In old age, the promontories have been worn away to a certain extent, while sand, brought from elsewhere by current and tide, has formed banks and spits across the mouth of inlets and estuaries, which are also being filled up by débris and mud brought down by rivers and streams.

LESSON 11

Stages in Map-Making

Maps are at the same time highly useful and extraordinarily fascinating. Titles to landed property and boundary rights ultimately depend upon maps. Probably the most interesting piece of work achieved by a great explorer is the map he produces to illustrate his journeys. The traveller sometimes finds considerable annoyance, and at other times a rare delight, in discovering that the official maps contain a mistake. We have, here, to consider how maps are made, and it will be advisable to examine briefly the principles which are involved in the field work which precedes accurate map-making. The first step is to consider the geometrical figure, the triangle.

The shape of a triangle depends entirely upon the sizes of two of the angles. Triangles of the same shape have their sides in the same proportion; for example, if the side adjacent to the two specified angles in one triangle is a foot in length, and the corresponding side in a second triangle of the same shape is two feet long, the remaining sides of the smaller triangle are each half of the corresponding sides of the larger triangle.

If we wish to make a map of our home surroundings we may proceed to use the above fact. From a pole fixed in the garden we measure the distance to a pole fixed in a neighbour's garden, say, exactly 100 yards from our pole. The line between the poles is the *base line*. From our pole we point a stick along the base line, and swing the stick over a graduated circle placed horizontally until it points at the neighbouring church spire; we then record from the circle 'the angle of swing.' Similarly, we measure the angle of swing when the stick is pointed to, say, the factory chimney, the school belfry, the telegraph post on the roof of the post office. From the second pole we measure in the same fashion the angles of swing to the same points, and we get the following record:

Angle of Swing

	From our pole	*From the second pole*
To church spire	80	80
,, factory chimney	45	110
,, school belfry	130	30
,, post-office	80	70

Note.—The post office is on the opposite side of the base line from the other buildings.

We now proceed to make the map. On a scale of 1 in 600, 100 yards is represented by 6 inches. Draw a straight line 6 inches long, plot the angles specified above, and extend the lines until they meet. The result is similar to Fig. 33, which is drawn on a scale of 1 in 7,200, or 1 inch = 200 yards. Having drawn the map, we can use it to discover the distance from one of the six points to any of the others. Since it is necessary to draw a triangle for each point sighted from the ends of the base line, the principle here illustrated is called *triangulation* (*see* further in page 390).

Map-Making Instruments. The instruments which are used for triangulation all depend upon the measurement of angles.

A prismatic compass gives the bearings of each line of sight, and from these the angle of swing is calculated. To facilitate sighting, metal pieces with slits and wires are attached to the compass.

A *theodolite* consists of a telescope for sighting purposes, specially where the distances are great, and two graduated circles, one horizontal and one vertical, on which are read the angles of swing and tilt respectively of each object sighted.

It is sometimes desirable to get the triangulation drawn as the sighting is performed. This method obviates the reading of angles in degrees and fractions of a degree, and yields a map drawn out of doors. The instrument for this purpose is a *plane-table*, of which the essential parts are a horizontal drawing-board and a sighting ruler—i.e. a ruler fitted with metal uprights as in the prismatic compass, to ensure accuracy.

In every case, however, the length of the base line is measured. For this purpose a *surveyor's chain* is usually used. A second principle of surveying is embodied in the method of *off-sets*, illustrated in Fig. 34. This method can be carried out with a chain and a cross-staff, but it can only be used when the surveyor actually goes to the points at the ends of each of the off-sets.

Such a necessity limits the usefulness of the method, because it confines it to small areas which are free from obstructions on the ground. The *cross-staff* is an instrument by which the surveyor is able to make sure that each off-set is at right angles to the base line.

Specimen Survey. The way in which these survey methods are used for map-making may be illustrated by the following proposition:

A commercial air route is under plan across an extent of ocean. An aerodrome with landing and repairing facilities is required about halfway across. An island, Mañana, promises a suitable site, but there are no good maps of the island. A party of surveyors is sent to make the desired map as a basis for the purchase or lease of the whole or part of the island.

The surveyors approach the island from the north-west, and see the view shown in Fig. 35. They proceed to determine the latitude and longitude of the three Capes, A, B, and C.

A boat party is landed at Cape A about 11.30 a.m. The angular elevation of the sun above the horizon at the precise moment when the sun is highest in the sky is measured with a sextant: the value obtained is 62° 15′ 30″. The time registered by a chronometer which keeps Greenwich time at the moment of the sun's maximum altitude is 10 p.m. The surveyor proceeds to make the following calculation: The sun's altitude at local noon at Cape A is 62° 15′ 30″—i.e. the sun's distance from the zenith is 90°—62° 15′ 30″ i.e. 27° 44′ 30″. Therefore 27° 44′ 30″ is the difference between the latitude of Cape A and the latitude of places where the sun is exactly overhead on this day.

According to the 'Nautical Almanac,' on this day the sun is overhead at lat. 10° 19′ 30″ N. Then the latitude of Cape A is 27° 44′ 30″ + 10° 19′ 30″ N: i.e. 38° 4′ 0″ N.

Because the Greenwich time of local noon is 10 p.m., Cape A is $\frac{10}{24}$ of 360° west of Greenwich, i.e. 150° west longitude.

By circumnavigating the island and landing boat parties at the several capes, the explorers are able to make sketches of the coast views and to determine the latitude and longitude of the chief capes. From their observations a *first* map is made, Fig. 36, on which the positions of the Capes A to F are accurately fixed, and details of mountain peaks and of rivers are merely sketched in.

Fig. 36 is merely a diagrammatic map made within a square of which the sides represent one degree of longitude or one degree of latitude. One degree of latitude is always the same length, 60 nautical or geographical miles and nearly 70 English or statute miles; but one degree of longitude may be merely one statute mile, if it is measured from east to west near the North Pole, or nearly 70 statute miles, if measured along the equator; consequently, Fig. 36

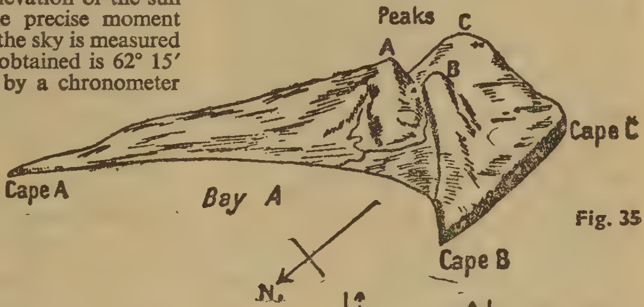


Fig. 35

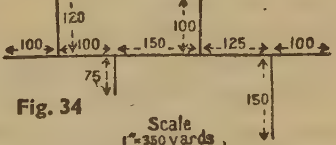


Fig. 34

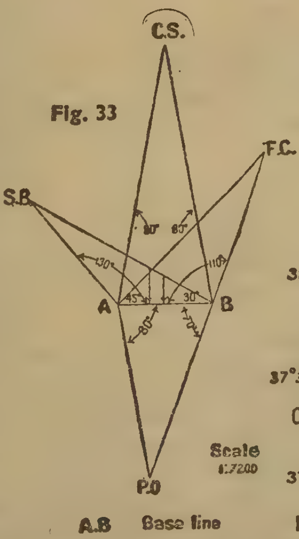


Fig. 33

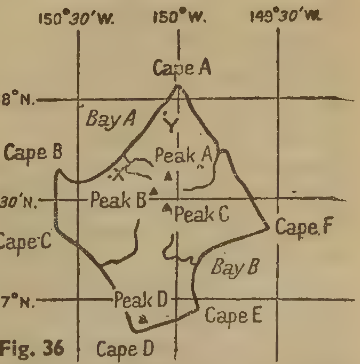
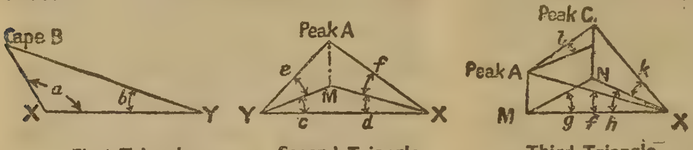


Fig. 36

BASIC PRINCIPLES OF MAP-MAKING. Figs. 33-36. These diagrams refer to methods of making a survey which are detailed in the text.

distorts the shape of the island by making it appear broader than it really is. This distortion is not a matter of great importance in a diagram such as this.



First Triangle Second Triangle Third Triangle

HOW A SURVEYOR WORKS. Fig. 37. Methods of measurement used in surveying the island sketched in Fig. 35. The whole island is covered by a network of primary triangles, the angles from point to point being determined and measured with the aid of a special instrument, the theodolite.

Triangulation in Map-Making. In page 389 we supposed that a boat party had landed on the island of Mañana to make a survey and map, with a view to ascertaining whether the island would be suited for an aeroplane base. Having pitched their camp near the mouth of the stream on the shores of Bay B, on the first clear night the surveyors proceed to check the latitude of Cape F by measurement of the altitude above the horizon of the Pole Star (the latitude of a place is always equal to the altitude of the Pole Star above the horizon measured at that place), which is found to be 37° 21′ 0″. Meanwhile, a wireless installation at the camp puts them into rapid touch with the rest of the world, and the longitude is checked by exchanging messages with the nearest observatory.

The surveyors tramp about on the island to find the largest possible stretch of level ground. They decide on the line X Y along the shores of Bay A, and proceed to measure the length of X Y as accurately as possible; it is found to be 40 miles. The line X Y is the base line for the primary triangulation of the island which is next determined by the methods described below.

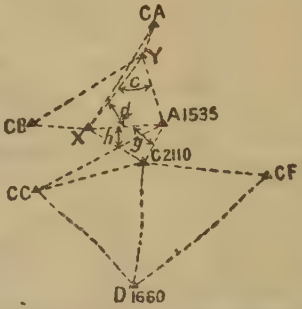


Fig. 38. Parts of the primary triangulation established in the island survey.

The First Triangle. Theodolites are erected at X and Y, and the angles to Cape B from these places are determined (Fig. 37). Angle *a* is 120° and *b* is 30°. From the known length of X Y and the angles 120° and 30° the distances of Cape B from X and Y are calculated.

The Second Triangle. The angles from X and Y to Peak A are measured; first the angles of swing, *c* and *d*, and then the angles of tilt above the horizontal, *e* and *f*. The air triangle, X Y Peak A, will appear on a map as the triangle X Y M, and from the known length of X Y and the angles of swing, *c* and *d*, the lengths of M Y and M X are calculated. Using the length M X, and the angle of tilt *f*, the height of Peak A is calculated. By using the length M Y and the angle of tilt *e*, the height of Peak A is determined again, and this last calculation serves to check the whole piece of work.

Up to the present the horizontal base line is used to determine the horizontal first triangles, X Y Cape B and X Y Cape A; and also to determine the positions and heights of Peaks A and B, both of which are visible from X and from Y. But Peak C is not visible from Y, so the line M X and the angle of tilt *f*, which have already been determined, are used in the third triangle.

The Third Triangle. It is usual to mark the precise points sighted with the theodolite by flagstaffs or cairns, so that the theodolite is transferred from Y to the cairn on Peak A, and the angle of swing *g* and that of tilt *l* are measured, while the angles of swing and tilt, *h* and *k* respectively, are measured from X. From these observations the lengths of M N and N X and the height of Peak C are calculated.

By using the line from Peak A to Peak C a third triangle is used to fix the position of a cairn erected on the top of the cliff at Cape C, and from this cairn and Peak C the position and height of Peak D are fixed.

In this fashion the whole of the island is covered by a network of primary triangles, of which the first few triangles are shown diagrammatically in Fig. 38. This method of map-making depends upon the principle of *triangulation.*

The surveyors have now reached a stage when they know the island fairly well, and they decide that there are two possible sites for the aerodrome, one near the shore west of Cape F and the other on a plateau north-east of Peak D. Consequently, the whole area of the triangle C D Cape F (Fig. 38) is more accurately surveyed by a series of smaller secondary triangles, with the result that (i) the coastline of Bay B, (ii) the course of the river which enters the bay, (iii) the situation of the ridges which radiate from Peak C, (iv) the steep edge of the southern plateau, (v) possible railway routes from a settlement near the mouth of the river to each of the aerodrome sites, are all accurately fixed upon a map, as seen in Fig. 40.

Completing the Survey. Three other pieces of work remain to be done: (a) the survey of the course of the main rivers in connexion with the possible water supply for the town settlement and the aerodrome, and in order to determine the best sites for farm settlements; (b) a still more detailed survey of the immediate neighbourhood of the aerodrome sites; and (c) a fairly elaborate and detailed survey of the site for the proposed town settlement and for harbour works.

A rapid survey of the main river valleys is carried through with (i) an aneroid barometer, (ii) a plane-table, and (iii) a prismatic compass. The surveyor reaches the river and fixes the location of a prominent landmark on the bank, chosen for its convenience, by taking compass bearings from two or more of the cairns used in the primary triangulation; he proceeds along the river and draws on the plane-table lines of sight to landmarks on the river bank and to the cairns. At each landmark he determines his height above sea-level by means of the aneroid.

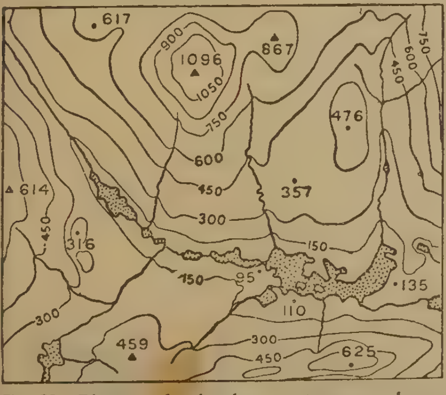
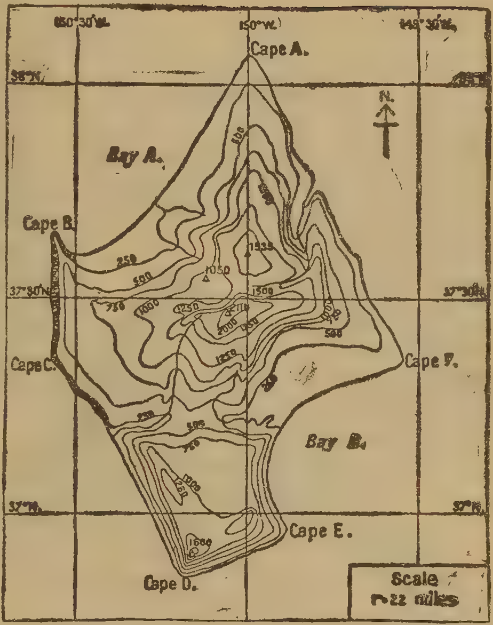


Fig. 39. Diagram showing how contours are drawn from spot heights.



CONTOURED MAP. Fig. 40. Final result of the survey of the island Mañana (see Fig. 35), by which suitable sites were determined for aerodromes and settlements.

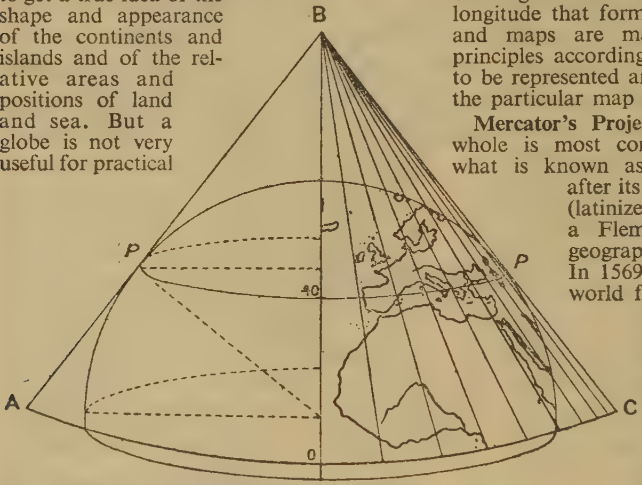
Contours. As a result of the plane-table work a series of sketch maps is made on which 'spot-heights' are marked, as in Fig. 39. These spot-heights are used to sketch in contours or height-lines.

Such sketchy contours are not sufficiently accurate for use regarding the rival merits of the two possible aerodrome sites, so that the surveyors, equipped with chains, surveyors' poles, and theodolites, proceed to make detailed surveys of the flat, almost level areas which they have selected. On these surveys the contours are shown for every 25 feet; and the sketch contours for these areas are carefully corrected. Finally, with chain and theodolite a plan of the proposed town settlement is 'pegged out,' and a map constructed. The final results of the survey comprise a map of Mañana, such as Fig. 40, and large scale plans of the two aerodrome sites and the town site. Photographs taken from the air are valuable in making a preliminary choice of an area for a particular purpose, and in checking the surveyors' general results, but ground work remains necessary for detailed mapping (*see* Aeronautics, Vol. IV, p. 135).

LESSON 12

Methods of Map Projection

As the world is a sphere, it can be accurately depicted only on a globe, and everyone would be well advised to study the world mapped on a globe in order to get a true idea of the shape and appearance of the continents and islands and of the relative areas and positions of land and sea. But a globe is not very useful for practical purposes such as navigating a ship or planning a campaign, and maps in the flat have therefore had to be devised. Various mathematical methods have been invented for drawing the network of lines of latitude and longitude that forms the basis of all maps; and maps are made on these different principles according to the size of the area to be represented and the purpose for which the particular map is required.



SIMPLE CONIC PROJECTION. Fig. 41. Diagram showing the principle of the projection: cone A B C imposed upon sphere and touching it at P.P.

Mercator's Projection. The world as a whole is most commonly represented on what is known as Mercator's projection, after its inventor Gerard Kremer (latinized to Gerardus Mercator), a Flemish mathematician and geographer of the 16th century. In 1569 he made a chart of the world for the use of seamen, in which the meridians of longitude, like the parallels of latitude, were represented as parallel to one another from north to south instead of converging until they meet at the north and south poles. Fig. 12 (p. 369) and Fig. 25 (p. 379) are drawn on Mercator's projection. Distances north and south of the equator are correct, but only at the equator itself are distances east and west

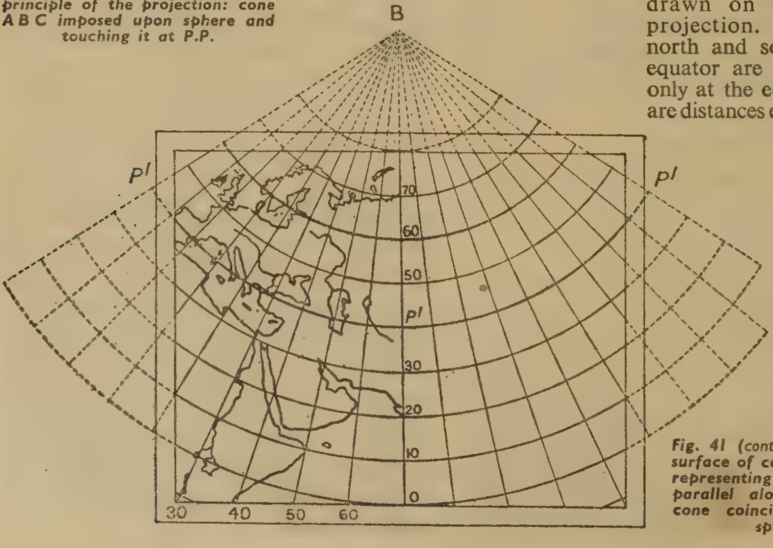
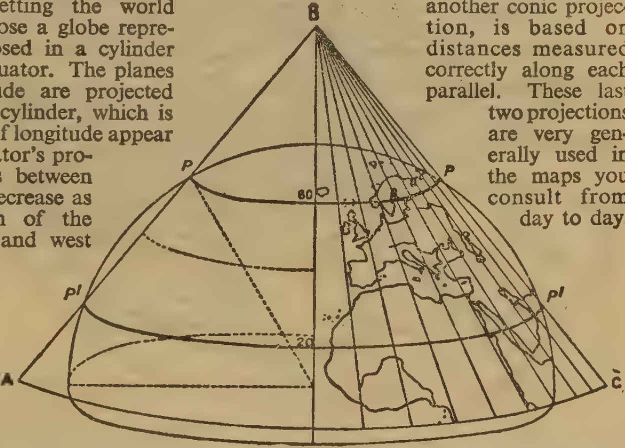


Fig. 41 (cont.). Portion of surface of cone spread out representing map; P'P', parallel along which the cone coincides with the sphere.

really correct, so that the shapes of the areas shown are distorted, and the farther north or south the country represented, the greater the exaggeration of its 'spread' from east to west, and therefore of its size. For instance, in a map drawn on Mercator's projection, Canada appears to be something like twice the size of the United States. In fact it is approximately one-fifth larger.

Cylindrical Equal-Area Projection is another simple way of getting the world mapped in the flat. Suppose a globe representing the earth is enclosed in a cylinder which touches it at the equator. The planes of the parallels of latitude are projected horizontally to touch the cylinder, which is then unrolled. Meridians of longitude appear to be parallel, as in Mercator's projection, but the distances between the parallels of latitude decrease as one goes north or south of the equator. Distances east and west are correct at the equator, but no other distances are true. On the other hand, the areas are correct, and this projection is therefore useful when a map is required to show relative areas.

Conic Projections. The plane of the projection in a simple Conic projection (Fig. 41) is the surface of an imaginary cone placed over the earth so that its point is above the pole in line with the projected radius of the earth through the pole, and it touches the earth all round at a given parallel. Distances along this parallel are correct, but there is distortion in the east-west direction north and south of it. The Secant Conic projection (Fig. 42) increases exactness by imagining the cone as partially sunk in the earth and cutting it along two parallels, along both of which distances are correct. Bonne's, another conic projection, is based on distances measured correctly along each parallel. These last two projections are very generally used in the maps you consult from day to day.



SECANT CONE PROJECTION. *Fig. 42. Diagram showing the principle of the projection: cone A B C imposed upon sphere and cutting it all round through P P'.*

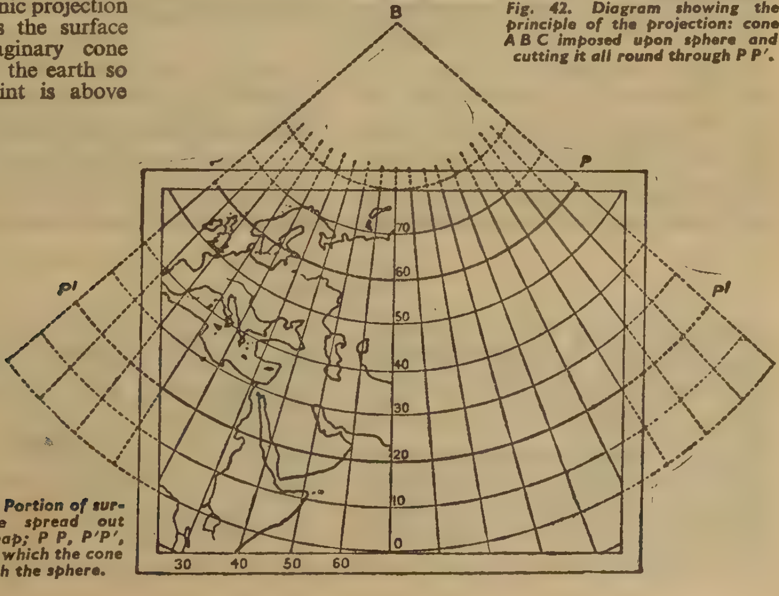
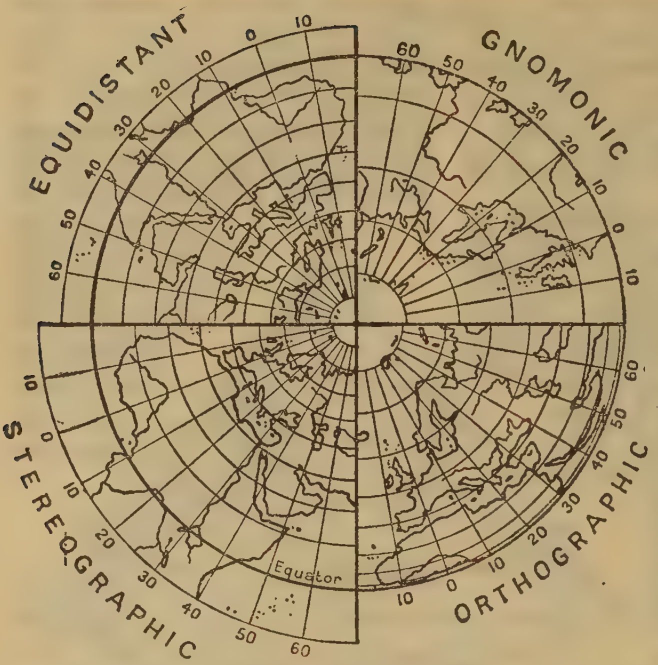


Fig. 42 (cont.). Portion of surface of cone spread out representing map; P P, P'P', parallels along which the cone coincides with the sphere.



POLAR PROJECTIONS. Fig. 43. Diagram showing four types of perspective projection. The Gnomonic projection cannot be made to include the whole hemisphere. The Stereographic and Equidistant projections can be extended to include more than the hemisphere.

Perspective Projections. A number of projections have been invented which aim at giving a truer perspective view of the world. In these, the meridians are shown converging to the north or to the south, according to whether the map is of an area north or south of the equator. The Gnomonic projection is based on the assumption that the eye surveying the world is at its centre; the Orthographic on the assumption that the eye surveys the world from an infinite distance; the Stereographic on the assumption that the eye is on the surface of the globe opposite the surface to be mapped. The Equidistant or Globular is a modification of the Orthographic and Stereographic projections. The different results for the same area mapped on these four projections are shown in Fig. 43.

Mollweide's Homalographic projection (used in Figs. 20 and 21, pp. 375–376, and in Fig. 23, p. 378) is an equal-area projection in which the complete circle on the map equals the world hemisphere, and the parallels are drawn so that the zone enclosed by them has the same relation to the circle as the actual zone on the earth has to the hemisphere. In Sanson-Flamsteed's projection, the parallels are drawn at their true distances from the equator, and the distances between meridians are correct at each parallel. There are other projections; but enough has been said to indicate the principles on which countries and continents are mapped.

BOOK LIST

General. 'Physical Basis of Geography,' S. W. Wooldridge and R. S. Morgan (Longmans); 'Earthquakes and Mountains,' H. Jeffries (Methuen); 'The Unstable Earth: Some Recent Views in Geomorphology,' J. A. Steers (Methuen); 'A Study of the Oceans,' J. Johnstone (Arnold).

Climate. 'Climate Through the Ages,' C. E. P. Brooks (Benn); 'Climatic Changes: Their Nature and Causes,' E. Huntington and S. S. Visher (Oxford Univ. Press); 'Climates of the Continents,' W. G. Kendrew (Oxford Univ. Press); 'The Climate of the British Isles,' E. G. Bilham (Macmillan); 'Climate: a Handbook for Business Men, Students and Travellers,' C. E. P. Brooks (Benn).

Cartography. 'Maps and Survey,' A. R. Hinks (Cambridge Univ. Press); 'A Key to Maps,' H. S. L. Winterbotham (Blackie); 'Exercises in Cartography,' F. Debenham (Blackie); 'Introduction to the Study of Map Projections,' J. A. Steers (Univ. Lond. Press); 'Map Reading Made Easy,' C. C. Eason and G. S. Philip (Philip).

RADIO AND TELEVISION

Advances in radio reception in recent years, together with a reduction in the number of types of receiver designs, make it practicable to present a simple, yet technically satisfactory, summary of the theory and practice of modern radio. Beginning with the basic theories of electron discharge, tuned circuits and the carrier wave, we consider the many varieties of modern compound valves, amplification, detection and output stages. Special attention is given to the modern tuned R.F. and 'superhet' receivers which have almost entirely displaced the older circuit arrangements. A note on Television concludes the Course.

The reader who wishes to pursue his studies of electron theory should consult PHYSICS (*Vol. I*) *and* CHEMISTRY (*Vol. III*).

12 LESSONS

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Circuit diagrams in this Course by courtesy of 'The Wireless World'

LESSON ONE

Fundamental Ideas in Radio Practice

During the last hundred years service after service has been made available to the Englishman in his private house. After water came gas for cooking and lighting, then electricity, supplying invisible energy along wires, followed by the telephone, bringing, again along wires, the speech of private friends at a distance. Then came sound broadcasting, bringing public entertainment into the home by means of invisible waves in an intangible ether. Last, and most wonderful, we have television, supplying the visible counterpart of sound broadcasting, again achieved by invisible waves.

The apparent absence of any physical link by which this entertainment can enter the home, together with the incalculable value of the entertainment brought and the ease with which a home-made equipment, however ramshackle it may be in appearance, can put its owner into touch with all the world, has made radio-telephony at once the most fascinating and the most mysterious of hobbies. To dispel a little of its mystery and, if that be possible, to add a little to its fascination is the object of this Course.

We will return to the subject of television at the end of the Course.

The Radio and the Telephone. Fundamentally, the radio only differs from the ordinary telephone by the fact that the messages it brings are conveyed by an ether wave instead of being transmitted along a wire. It is true that this difference, although trifling enough to be set forth in a few words, is at the same time great enough to have brought into being the whole new science of high-frequency engineering, and has enabled any man with a receiving set to pick up music and speech from any transmitter within a radius of many hundreds of miles. The bald, simple fact remains that radio apparatus, both transmitting and receiving, is at bottom an ordinary telephone with an invisible link replacing the usual wire.

Unless, therefore, we have at least a general acquaintance with the principles on which the household telephone works, we can never even begin to grasp what goes on in a radio set; we shall thus be forced to begin our discussions with this earlier and simpler device. But the telephone, in turn, is just one application of electrical science in general, and involves for its comprehension a knowledge of such electrical facts as bear upon it. Unless, therefore, our knowledge of radio is going to be so sketchy and superficial that it is, in reality, no knowledge at all, we must inevitably go still further back to a consideration of some of the fundamental facts of electricity and its behaviour, in terms of which the telephone and its younger sister, radio, can be described.

What is Electricity? Although electricity is very familiarly spoken of by everyone, nobody has any real knowledge of what it is. Fortunately, that is not of much importance, for scientists have studied it so extensively in the last hundred years that they know very exactly what indeed it does, which is all that really matters. A convenient view, and one that, as far as it goes, is reasonably accurate, is to regard electricity as identical with *electrons*.

The electron is known to be one of the bricks from which the atoms of every conceivable substance are built up, and although their exact nature is to some extent in dispute, for our present purposes we shall be quite safe in regarding them as inconceivably minute material particles which carry about with them wherever they go a small but definitely fixed quantity of electricity.

A rough idea of the inner structure of an atom is given in the diagram (Fig. 1), the sign + standing for a unit charge of positive and the sign − for a unit charge of negative electricity. All the weight of the atom appears to reside in the central nucleus, made up of more positive than negative charges, so that a positive charge is always associated with a relatively large amount of matter. Electrons, on the other hand, are almost weightless, and so can carry on a separate existence as (almost) disembodied electricity. (For further discussions on the electron *see* the Courses on Physics, Vol. I, Lesson 17, and Chemistry, Vol. III, Lessons 26 and 27.)

In ordinary uncharged matter the electricity that they carry is neutralized by the net positive charge on the nucleus of the atom; that explains why it is that, although electrons are present in every substance, we do not suffer shocks when we touch anything.

Movement of Electrons. A source of electricity, whatever its nature, ought really to be called a source of electrons, this last phrase meaning that the free-flying outer electrons are there separated from their parent atoms and made to exist or move alone. In a battery, electrons are freed by a chemical process, while in a dynamo they are pulled from their atoms and set in motion by magnetic influences. All the electrical phenomena of everyday life depend on the movement of electrons.

If we consider the case of the ordinary accumulator cell as used for radio sets, we shall begin to see how electrons move. By virtue of the chemical reactions taking place within it, the negative plate of the battery is fed with an excess of electrons, while at the positive plate there is a deficiency. If no way is provided by which these electrons can move round from the negative to the positive plate, they collect at the former until they are so crowded there that the chemicals can force no more electrons in. There are many types of cell, each with its own chemical make-up; but for each there is a definite electron pressure, which it will maintain as long as it is in good condition, and which it can in no case exceed. This electrical pressure is measured in volts, and is commonly called voltage, rather than electrical pressure.

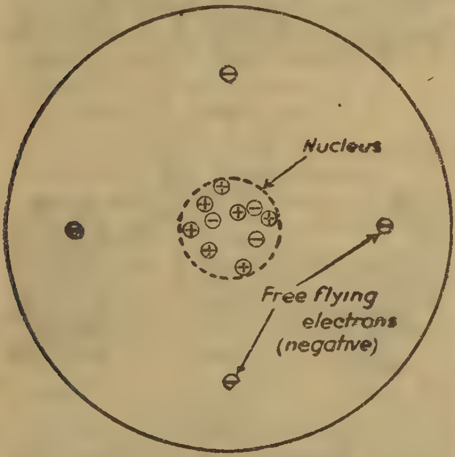


Fig. 1. SKETCH OF INNER STRUCTURE OF AN ATOM. *The central nucleus has more positive than negative charges and outside it are sufficient free-flying electrons to balance this excess.*

If the terminals of the accumulator are now joined with a piece of wire, the wire will get hot, and if the connexion is intermittent there will be sparks. These evidences show that the electrons accumulated on the negative plate are finding their way along the wire to the positive plate, at which there was a deficiency. The flow is maintained after the first rush of electrons has passed by the chemical reactions in the cell, which, while the chemicals last, will continually strive to keep up the original difference in electrical potential, or electron concentration, between the two plates.

The Electric Current. This flow of electrons constitutes an electric current, and might very reasonably be measured in electrons per second. Owing to the smallness of the electron, such a description of any useful current would lead to inconveniently large numbers, and it is customary to take as the unit a body of about six million billion (6,000,000,000,000,000,000) electrons or, in mathematical form, 6×10^{18} electrons. A wire along which one of these vast crowds passes in each second is said to carry a current of one ampere.

It must not be imagined that the electrons which reach the positive plate of the cell are the same individual electrons that entered the wire from the negative plate. A truer picture is obtained if we imagine a continuous random movement of electrons from atom to atom within the wire. When an electrical voltage is applied, this random movement has superposed on it a trifling drift in one direction, so that the normal nearly perfect balance between east-bound and west-bound electrons is very slightly disturbed.

Reverting to the accumulator cell, it will be evident that if the wire joining its terminals is short and thick, a bigger current will pass along it than if it is long and very thin; for, in either case, the pressure driving the electrons—that of the cell—will be 2 volts. As an analogy, compare the water-flow, in gallons per minute, through a short, wide pipe with that through a long, narrow tube. The thin wire, like the narrow tube, offers resistance to the flow. In the electrical case, this resistance is measured in units called ohms.

Ohm's Law in Radio. Having introduced the three fundamental electrical units of pressure, of current, and of resistance, we have to consider their relationship. This is summed up in a simple and fundamental rule known, in honour of its discoverer, as Ohm's Law. This rule is: Pressure in volts divided by resistance in ohms equals current in amperes; or in symbols:

$$I = \frac{E}{R}.$$

Thus 2 volts drive 1 ampere through 2 ohms, but only ½ ampere through 4 ohms.

Further, from any two of the quantities the third can be deduced; if a valve filament takes

0·1 amp. at 2 volts, its resistance is 20 ohms ($R = \frac{E}{I}$).

Or if 5/1000th ampere flows through 10,000 ohms, the voltage or potential difference across the resistance must be 50 volts ($E = IR$). The reader will be well advised to make up and work out examples enough of Ohm's Law to make him completely familiar with it in all its bearings.

No radio engineer would ever describe a current as 5/1000th ampere, as was done just now; he would speak of '5 milliamps.' 'Milli,' and other prefixes of the metric system, are very widely used in all scientific work. The following are the most usual:

Milli—meaning one thousandth of. Symbol m.
Micro—meaning one millionth of. Symbol μ.
Kilo—meaning one thousand. Symbol K.
Mega—meaning one million. Symbol M.

Thus a million ohms is a megohm; a thousandth of an ampere a milliampere ('milliamp' in speech); a millionth of a volt a microvolt; and a frequency of 1,000 cycles per second is called one kilocycle per second. All these odd-sized units, and many others, may be invented whenever they are needed: the prefixes are regarded as absolutely universal. It would be quite in order, for example, to say that light takes 5·4 microseconds to travel a mile, or that the distance from the earth to the sun is 93 megamiles.

Resistance. But whatever units we may use for resistance, current and voltage, it is essential to revert to ohms, amperes and volts (symbols Ω, A, and V) before using Ohm's Law. To see this, try working out the resistance through which 10 mV will drive 5 μA. Remember that 10 mV can be expressed as 10,000 μV, or as 0·01 V, and 5 μA as 0·005 mA, or as 0·000005 A. Try various combinations of these possibilities. In case of bewilderment, the fact that 2,000 Ω is the correct answer may serve as a sheet anchor.

Reverting to our accumulator cell, it may be a matter of wonder that current does not flow through the glass, pitch or celluloid in which both terminals are embedded. The reason is simply that the resistance of these substances is practically infinite. They, together with ebonite, bakelite, dry wood, india-rubber, porcelain and many other substances, are, therefore, known as *insulators*. In a conductor, such as copper wire, electrons can be handed along from atom to atom like buckets along a chain of fire-fighters—an electrical voltage, of course, being needed to set this process in motion. In an insulator the electrons are too firmly fixed in their places to leave the atom altogether, but an applied voltage can cause them to move a little—rather as though they were tied to their atoms by elastic.

Condensers and their Capacity. The analogy is a good one, for the extent to which they move depends on the voltage urging them, and when the voltage is removed they spring back to their normal places. This is seen best in a *condenser*, which consists of two plates separated by a very thin layer of insulating material known as the *dielectric*.

If we have a large condenser, of capacity perhaps 2 microfarads (2 μF or 2 mfds), and connect it up, as shown in Fig. 2, in series with a 100-volt wireless battery and a pocket-lamp bulb, we shall see the lamp light up brilliantly for an instant and then go out. This momentary brilliance was due to a surge of electrons into one plate of the condenser, resulting in the limited elastic displacement of the electrons in the dielectric and the consequent expulsion of a like number of electrons from the other plate.

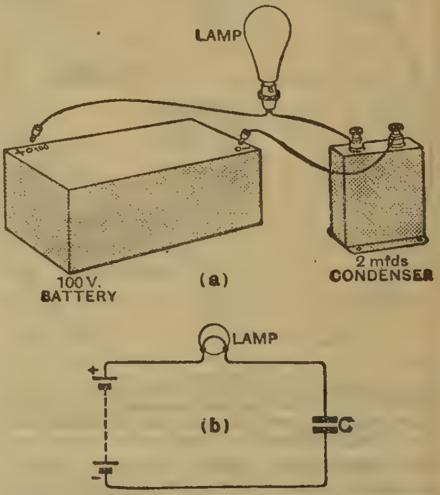


Fig. 2. THE CONDENSER. (a) Pictorial representation of a circuit containing a condenser; (b) the same with the more usual symbols. The battery charges the condenser, the lamp flashing momentarily as it does so.

As this elastic movement reached its limit the surge of electrons had to stop, and the lamp went out. There was, for an instant only, a flow of current *through the insulating material* forming the condenser dielectric.

After the current had ceased the dielectric was in a state of strain, which we usually express by saying that the condenser is *charged.* Proof of this can be had by removing the wires from the battery and touching them together, when the lamp will again light for an instant. This is due to the displaced electrons in the dielectric springing back to their normal position, sending a surge round the circuit in a direction opposite to that which occurred on charging. The condenser is now said to be *discharged.*

The size, or *capacity*, of a condenser is rated in terms of the number of electrons which is driven through it on the application of a pressure of one volt. If this number is the same unit 'crowd' (6 million billion) of electrons, the passage of which in one second constitutes a current of one ampere (*see* page 397), the condenser is said to have a capacity of *one farad* (F). Such a condenser would be enormous; the practical unit is the microfarad (μF).

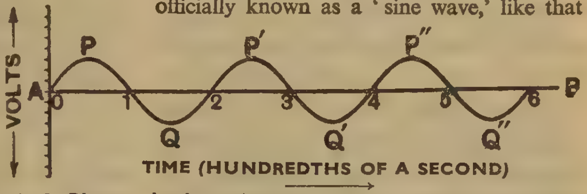


Fig. 3. Diagram showing variation with time of an alternating voltage. The shape of the curve (here a sine wave) indicates the 'wave-form.'

Alternating Current. The reason that the battery of Fig. 2 would only send a momentary current through the condenser was that, once displaced, the electrons in the dielectric could not move further. If, instead of a battery delivering a steady unidirectional voltage, we use a source of voltage that reverses its direction a hundred times a second, matters are rather different, for the condenser is no sooner charged than the reversal of voltage discharges it and recharges it in opposite polarity.

If a piece of wire were to replace the condenser, electrons would be driven to and fro in just this same way as the voltage continuously reversed its direction, though in this case the current would be larger, because the elastic resistance of the 'tethered' electrons in the dielectric would no longer be present. A condenser thus allows an *alternating voltage* to drive electrons through it (actually 'in and out of it') without limit of time, just as a piece of wire would allow the same voltage to drive electrons through it (actually 'to and fro in it'). Connect a 40-watt lamp and a 2μF condenser in series with alternating mains, and the lamp will light and stay alight.

An alternating voltage or current is conventionally represented by a wavy line officially known as a 'sine wave,' like that of Fig. 3. The line AB is the zero line and represents zero voltage or current. Any point above the line represents voltage in one direction, points below representing voltage in the opposite direction. Movement from left to right indicates the passage of time. The voltage rises at P to a maximum in one direction, falls away again to zero, rises at Q to a maximum in the other direction, and then returns to zero, only to begin the whole business over again. A reversal of direction occurs every hundredth of a second, and the complete double process, ending exactly where it began, occupies two-hundredths of a second. Such a process is called a *cycle*, and the number of cycles in each second the *frequency*. Fig. 3 depicts an alternating voltage (or a current, if we regard the vertical scale as amperes instead of volts) of the usual supply frequency 50 cycles per second.

LESSON TWO

Theory of the Tuned Circuit

We have seen that an alternating current can pass through a condenser; how can this current be estimated? The charging current of a condenser will clearly be greatest at the instant when the voltage is first applied, before the electrons in the dielectric are under appreciable strain; it follows that the faster the voltage-alternations the more use will be made of the first rush of current. With a higher frequency the current will, therefore, be greater, other things being equal, than with a lower frequency.

Condenser Currents. The actual value of the current is $2\pi fC \times E$, where f = frequency of voltage applied, C = capacity, and E is the A.C. voltage across the condenser. Comparing this with Ohm's Law, $I = E/R$, we notice that $1/2\pi fC$ has taken the place of R. This expression is known as the *reactance* X of the condenser and, like resistance, is expressed in ohms.

Note particularly that the reactance is not a characteristic of the condenser by itself, but depends also on the frequency of the voltage applied. Further, it differs from resistance in a more fundamental way still. The passage of a current through the latter involves an expenditure of energy in driving the electrons against the resistance; this manifests itself as *heat*, as in an electric lamp or a valve filament.

But except for the inevitable small resistance in the connecting wires, no energy is lost in the passage of an alternating current through a condenser, for the energy required to displace the electrons is returned to the circuit when they spring back on discharging. This can be shown very convincingly by connecting a condenser, an ammeter, a wattmeter, and a variable resistance all in series with A.C. mains. As the resistance is increased from zero the current falls, but the power, originally negligible, rises rapidly.

Electrical power is measured in *watts* (W), and is found by multiplying the pressure in volts applied to a resistance by the current through it in amperes: $W = EI$. Since $E = IR$, we can also write $W = I^2R$, giving wattage as current *squared* times resistance. The current driven through a condenser by an alternating voltage is called *wattless*; any dissipation of energy in the circuit is determined from $W = I^2R$, using for R, not the reactance of the condenser, which involves no consumption of power, but only the value of any stray resistance that may have found its way into the circuit. In the absence of any resistance the wattage would thus be zero, and the current truly wattless.

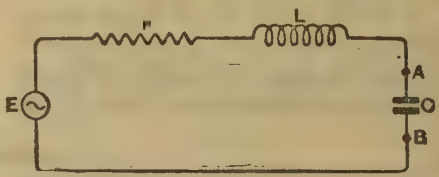
Inductance. Wattless current can also be drawn from an A.C. source by a coil of wire. As everyone knows, a coil of wire through which a current passes forms an electro-magnet, and to build up the magnetic field surrounding this electro-magnet energy has to be provided. If a coil is connected to a battery, the field is built up as the current rises to full value, after which the field ceases to change and the current continues at a value determined solely by the resistance of the coil. Of the total energy supplied by the battery, that first delivered is now stored in the magnetic field, while the rest is being dissipated as heat in overcoming the resistance of the wire.

On first connecting the battery, its voltage has to drive energy enough both for building up this field and for overcoming resistive losses. Faced with this double obstruction to its passage, the current rises slowly, reaching its full value only when the field is fully established, and the need for supplying it with energy is over. If a source of alternating voltage replaces the battery, the current never has time to reach full value before the next reversal in direction takes place, resulting in the collapse of the field and its re-establishment in opposite polarity.

When driven by an alternating voltage, therefore, the current through the coil is always less than that given by Ohm's Law ($I=E/R$), if we interpret R as meaning only the resistance of the wire. The total *impedance* (Z) of a coil is thus greater than its resistance by an amount depending on the magnetic field round it. The amount of the field produced by the coil for a current of one ampere is called its *inductance* (L) and is measured in henrys (H).

The total impedance it offers to alternating current depends on the frequency of the current as well as on its inductance and resistance; that part of the impedance depending solely on its inductance is called, as in the case of the condenser, reactance, and is numerically equal to $2\pi fL$ ohms.

If the coil had no resistance, the current would be $E/2\pi fL$ amperes, the reactance taking the place of resistance in Ohm's Law. This current requires no power to drive it, because each time the field collapses it returns to the coil the energy taken to build it up, just as the discharge of a condenser refunds to the circuit the energy previously taken to charge it.



SIMPLE TUNED CIRCUIT. Fig. 4. The reactances produced by condenser C and inductance L, fed from an A.C. source E through resistance r, must at some point be equal. This is resonance and is the basis of all radio tuning.

The Tuned Circuit. In Fig. 4 is shown a circuit in which a coil of inductance L, a resistance *r*, and a condenser of capacity C are all connected in series with E, a source of A.C. voltage. This combination gives us a circuit in which the charge and discharge of a condenser and the rise and fall of a magnetic field are taking place simultaneously.

It so happens that these two events tend to obliterate one another's effects; the energy required for the rising field is supplied at exactly the right instant by the discharging condenser, and the energy needed to recharge the condenser is supplied, again at exactly the right instant, by the collapsing field.

At low frequencies, where the reactance of C is high and that of L is low, the magnetic field of L can only supply part of the energy needed for the condenser; at high frequencies, where the reactance of L is high and that of C low the discharge of C can only provide part of the energy needed to establish the field round L. But there must be some intermediate frequency at which these two reactances are equal; at this frequency, and at this frequency only, the charge on C and the field round L involve exactly equal amounts of energy.

This frequency, at which L charges C, and C, in discharging, builds up again the field round L, is known as the *resonant frequency*. The reactances of L and C being equal at this frequency, we know that

$$2\pi fL = 1/2\pi fC$$

from which $f = 1/2\pi\sqrt{LC}$.

This expression for the resonant frequency will turn up pretty often later, and is, therefore, well worth noting.

Since L and C supply one another's needs exactly, the two jointly offer no reactance to the flow of current, which is therefore determined entirely by the value of r.

To make the example more concrete, and to show up some of the peculiarities of a resonant circuit, we will allot numerical values to the various quantities. Taking a radio example, let us make E = 1 mV (1 millivolt), C = 150 $\mu\mu$F (micro-microfarads), r = 15Ω (ohms), and f = 1,000 kc. From the relation $f = 1/2\pi\sqrt{LC}$, knowing f and C, we can find L, which comes out as 167·5 μH. (The careful student will check this and other calculations as he goes along. All working must be done in henrys, farads, cycles, etc.; milli-, micro-, and kilo-units generally give absurd results.)

Resonance and Tuning. At resonance, the total current is

$$E/r = 66{\cdot}6\ \mu A.$$

Since this current passes through L and C, it evokes across the one a voltage drop of

$$0{\cdot}0666 \times 2\pi fL = 70\ \text{mV.},$$

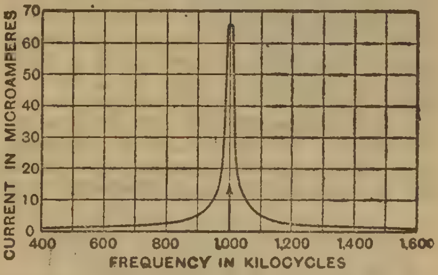
and across the other a voltage-drop of

$$0{\cdot}0666 \times 1/2\pi fC = 70\ \text{mV.}$$

The magnitude of these voltages, 70 times that of E, the voltage actually applied, is at first sight rather astonishing. It would seem to imply that there are 140 millivolts, not merely one, available to drive a current round the circuit. This is not really so, because the voltage across the coil and that across the condenser, although continually reversing in direction, remain at every instant *exactly in opposition*. Each, therefore, wipes out the other, and the voltage between B and C is at every instant zero.

In a radio set, this ability of a tuned circuit to magnify an applied voltage is turned to account; the voltage across C alone may be picked up at terminals A and B and passed on to the set.

The ratio of the voltage on C (or on L, since they are the same) to that injected at E is known as the Q value of the circuit. This is a numerical measure of the magnification of the circuit and also measures its selectivity, i.e., its ability to separate stations on adjacent wavelengths or frequencies.



RESONANCE.* *Fig. 5.* *Curve of tuned circuit in Fig. 4, showing current peak when frequency resonance occurs. Current is maximum at resonance when $2\pi fL = 1/2\pi fC$.

At frequencies other than that of resonance the current is smaller, since the reactances of L and C no longer exactly cancel. A curve showing the rise and fall of the current in the circuit of Fig. 4 as the frequency is slowly raised from 400 kc. to 1,600 kc., passing through the resonant frequency of 1,000 kc. en route, is given in Fig. 5. This is a typical resonance curve of a tuned circuit, showing quite clearly that if two voltages, one at 800 kc. and one at 1,000 kc., are simultaneously present, the latter, to which the circuit is tuned, will evoke by far the greater current.

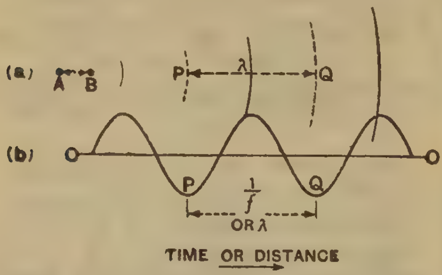
It is by this means that radio apparatus is *tuned*, the circuit being made to resonate to the frequency of the desired station by adjustment of a variable condenser connected in place of the fixed condenser C of Fig. 4.

LESSON THREE

Microphones and Loud-Speakers

The preceding Lessons contain enough material to form a respectable foundation of electrical knowledge. Using that, we can get a little nearer our true subject, the transmission of sound by electrical means. When two people in a room converse, they do so by a simple form of radio—there is certainly no visible link between them. The speaker, in producing his words, sets up vibrations in his organs of speech, and as these are in contact with the air, this also is set into vibration. In the form of invisible air-waves, the speech is carried across the room to the ear of the listener, where the movements of the air impinge on his ear-drum and, by moving it, stimulate certain nerves to transmit to his brain the words of the speaker.

It will be tolerably clear from all this that the key-note of the whole process is 'vibrations.' Let us see what happens when a solid object, such as a fiddle-string or a loud-speaker diaphragm, vibrates in air as suggested in Fig. 6a. A and B are supposed to show the end view of a vibrating string at the two extreme ends of its range of movement; it is to be thought of as moving rapidly from left to right and back again between these limits. We can represent its distance on either side of its central (non-vibrating) position at any instant by the sine-wave of Fig. 6b.



SOUND WAVES IN AIR. Fig. 6. (a) Waves sent out in air by vibrating string; full line = compression; dotted line = rarefaction. (b) The rise and fall of pressure at any one point plotted against time, or the distribution of pressure over a distance of 2½ waves at one instant.

In moving towards B the string pushes and compresses the air before it, the strength of the push dying away as the string slows up to reverse direction on reaching B. On the reverse travel it pushes air the other way (to the left), leaving behind it a momentary partial vacuum on the B side. Reversing direction again at A, it gives another push to the air on the right, and so goes on indefinitely. Like waves on the surface of water, the alternate compressions and rarefactions of the air travel outwards from the string; they are sound-waves. On arrival at a human ear they deliver to it alternate pushes and pulls at the same rate as those given by the string to the air. The pitch of the note heard is controlled by the rapidity of vibration, that is, by the number of complete travels from A to B and back again made by the string in each second, or by the number of complete 'waves' per second in Fig. 6b.

Determining Wave-length. If the frequency of the note is 330 cycles per second, it will be clear that the first compression-wave will have been travelling for 1/330th second by the time the next leaves the string. Since the rate of travel of sound in air is 330 metres per second (a metre is 39·4 inches), it will have moved just one metre, so that the second wave will follow at one metre's distance behind the first. The wave-length of this note, in air, is thus one metre.

If the frequency had been 660 cycles instead of 330, the first wave would have had only half as long a start of the second; the wave-length would then have been ½-metre. In general, wave-length λ equals velocity divided by frequency (P—Q, Fig. 6); for sound in air, therefore, we can use the formula $\lambda = 330/f$ metres.

The Microphone. If a vibration in the air can set up an exactly corresponding vibratory impulse in the nerve leading from ear-drum to brain, there is no special reason why it should not be made to set up a corresponding electric current in a wire from a suitably designed 'electrical ear.' Such an apparatus is called a microphone; there is one just behind the mouth-piece of the ordinary telephone.

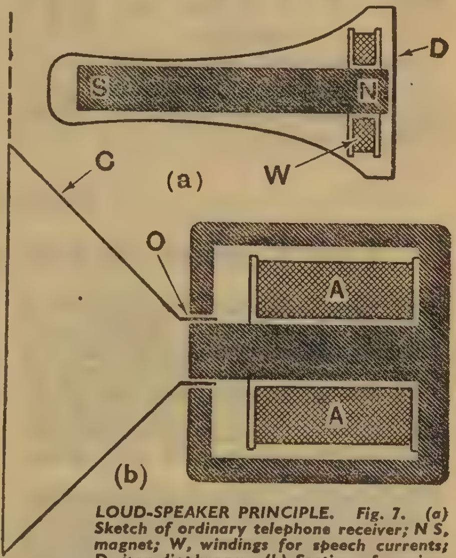
One type of microphone consists of two metal disks separated by loosely packed carbon granules. When sound-waves move the thin diaphragm forming the front disk, the degree of perfection of contact between these granules is altered, so varying the resistance of the microphone. If a steady current is passing through the microphone all the time, then when speech-waves strike the diaphragm the current will vary in such a way that its difference at any instant from the normal steady value will represent the air-pressure at that instant.

In other words, the current will take up the wave-form of the sound, so that the curve of Fig. 6b will serve to represent the variations of the current about its normal value, OO. With more complex wave-forms than this, which represents a pure note, the process is the same, so that even the involved variations of air-pressure set up by speech are faithfully transformed into electric currents which mirror them precisely.

Telephone Receiver. Once in the form of a current, speech can be transmitted along a wire to any distance. Arrived at their destination, the currents must be reconverted back into air-waves in order to make them intelligible. This is done by the telephone ear-piece, which consists, as Fig. 7a shows, of an iron diaphragm close to, but not quite touching, a magnet, round which are wound many turns of fine wire. As the speech-currents pass through this winding, they increase or reduce slightly, according to their direction of flow from moment to moment, the pull of the magnet on the diaphragm. This moves under the influence of the varying magnetic field, and as this field reproduces the current, and the movements of the diaphragm reproduce the field, the final result is to set up in the air waves which are a recognizable, if not always an exactly faithful, reproduction of the original air-waves falling on the microphone at the other end of the wire.

The Loud-Speaker. Loud-speakers, which have almost entirely replaced the telephone for wireless reception, are of two main types: moving iron and moving coil. In the former the principles of the household telephone are still used, though a tongue of metal attached to a large cone of paper or cloth replaces the small iron diaphragm. This type of speaker, though still used, has at least three drawbacks, two of which arise from the nearness of the armature to the magnet. The restricted movement of the armature prevents proper reproduction of low notes, for which big amplitudes are necessary, while tendencies to mechanical resonance and unsymmetrical movement with respect to the magnet impart a very definite coloration to music. The reproduction they give is often acceptable, but never quite faithful.

In the moving-coil speaker, the basic scheme of which is shown in Fig. 7b, the possibilities of high quality are greater. Here the speech-current is passed through a coil O, suspended more or less freely in a powerful magnetic field set up by a magnet, which may be a permanent magnet or one excited by the passage through its windings of a current. In passing through O the speech-currents set up round it a correspondingly varying magnetic field, which, acted upon by the steady field, causes the coil to move. To it is attached a paper diaphragm serving to transmit movements of the coil to the surrounding air. The travel of the coil in and out of the gap in the magnet having no very well-defined limits, bass notes up to a reasonable strength can be properly reproduced, while the symmetry of its structure and its comparative lack of resonances makes surprisingly faithful conversion of speech-currents into air-waves possible to the moving-coil speaker.



LOUD-SPEAKER PRINCIPLE. Fig. 7. (a) Sketch of ordinary telephone receiver; N S, magnet; W, windings for speech currents; D, iron diaphragm. (b) Section of moving-coil speaker; A, windings to energize magnet; O, coil suspended in gap of magnet; C, paper cone, supported round outer edge; baffle shown dotted.

This type of loud-speaker has now, in consequence, practically ousted all others.

Frequencies in Music. Reference to the piano keyboard (Fig. 8, p. 404), on which are marked the frequencies of the various notes in cycles per second, will reveal that for fullest reproduction of all musical notes, including harmonics, frequencies from 20 to at least 10,000 cycles must be handled by the speaker. It is a fact not to be ignored that modern receivers reproduce only up to about 4,000 cycles.

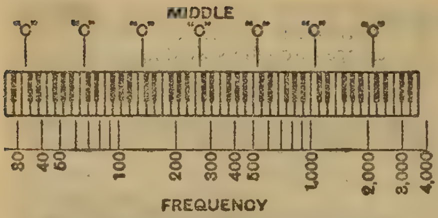


Fig. 8. Musical scale referred to in the text.

These are termed low or audio-frequencies and are represented throughout this Course by the initials A.F.

At the lowest frequencies movement of the cone is so slow that air pushed forward has time to get round to the region of reduced pressure behind it, and, unless prevented, it does in fact do this, so that the energy available fails to set up a sound-wave at these frequencies. The loss of bass that results can be avoided by making the length of the path from front to back of the diaphragm approach the wave-length of the low notes in question. For this the speaker is mounted behind a 'baffle' (dotted in Fig. 7b), consisting of a flat board or a cabinet with a hole fitting closely round the outer rim of the loud-speaker cone.

LESSON FOUR

The Carrier-Wave and its Modulation

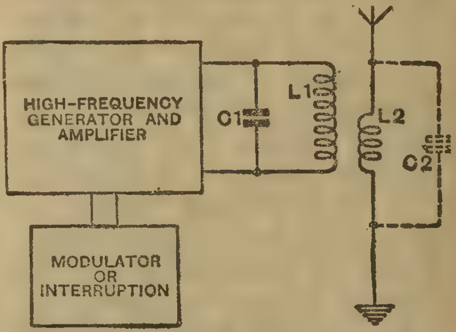
The musical scale at the end of Lesson 3 above showed that audible notes have frequencies up to some 10 or more kilocycles, while the upper limit of audibility (bat's squeak) is round about the 25 kc. level. Electric currents of these frequencies, since they would produce audible sounds if sent through telephones, are called audio-frequency currents.

The most direct method of wireless transmission would be to convert into currents, by means of a microphone, the music played in the studio, subsequently amplifying up these currents and passing them to an aerial for radiation into space. If this were done, there would be no means of tuning-in one station rather than another, because all would have to radiate currents covering the whole musical range, and an adjustment of the receiver that was right for one would be right for all. A further difficulty would be found in the fact that higher frequencies are radiated far more efficiently than low, which at once suggests that if frequencies even higher than the highest of the audible range were to be sent out, they would travel long distances even if the power behind them were quite small.

Radio transmission is based on this latter conception, the frequencies used for sound broadcasting ranging from 30 kc/s to 30,000 kc/s (30 mc/s). Such frequencies are termed high or radio-frequencies. We shall represent them by the initials R.F. to distinguish them from the lower frequencies in the A.F. spectrum.

The Carrier-Wave. In the simplest form of transmission, a continuous *carrier-wave* is radiated from an aerial. The apparatus used for transmission consists fundamentally of a powerful source of alternating current at a very high frequency, coupled in a suitable manner to an aerial. A scheme showing a possible coupling is given in Fig. 9. Here the high-frequency currents from the generator are fed into the circuit L_1C_1, which is tuned to the frequency of the generator by suitable choice of inductance and capacity. Being tuned, large currents pass through L_1, and this is so disposed in relation to L_2 that the alternating magnetic field set up by the passage of the current through the former cuts the latter, thereby inducing in it a voltage of the same frequency. These two coils are said to be *coupled*, since a current in one induces a voltage in the other.

L_2 is joined between aerial and earth, and


HIGH-FREQUENCY GENERATOR AND AMPLIFIER
C1
L1
L2
C2
MODULATOR OR INTERRUPTION

TRANSMISSION. Fig. 9. Scheme showing how radio-frequency currents are conveyed to an aerial for radiating. L_2 is tuned by the capacity between aerial wire and earth, shown dotted at C_2.

forms with them another tuned circuit. The capacity tuning L_2 is provided by the aerial-earth system, which acts as the two plates of the dotted condenser C_3. L_2 is given an inductance that tunes the aerial to resonance with the generator.

The large current flowing in this tuned aerial circuit develops a large voltage between aerial and earth. The variation of voltage on the aerial with time can be represented by the curve of Fig. 10a, typical of all alternating-current phenomena. This rhythmic variation of voltage sets up disturbances in the ether, causing a series of rhythmic electrical pulses to be sent out, just as the vibrating string sent out air-waves.

If the time occupied by each cycle is one-millionth of a second (f = 1,000 kc.), the first pulse will have been travelling for this time before the second leaves the aerial. A disturbance in the ether travels through it at the rate of 300 million metres per second (186,000 miles per second, the speed of light), so that, if f = 1,000 kc., the first will be 300 metres away when the next starts. In other words, the wave-length will be 300 metres.

As in the case of sound-waves, we can use a simple formula for finding the wave-length corresponding to an ether-disturbance of any frequency; the formula is $\lambda = 300{,}000/f$ metres (f in kc.). 'Medium-wave' broadcasting occupies the range 1,500 to 550 kc. (200 to 550 m.), while 'long-wave' broadcasting runs from 300 to 150 kc. (1,000 to 2,000 m.).

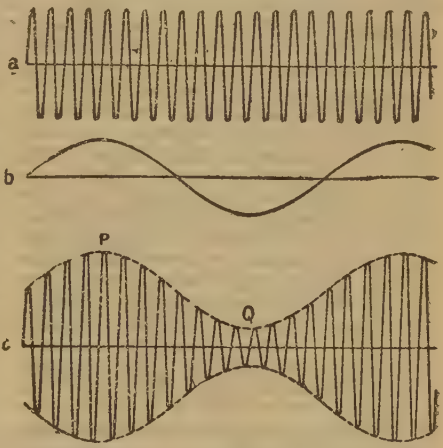
Short waves may be considered as ranging from 6·0 mc/s (50 metres) to 30 mc/s (10 metres) and ultra short waves from 30 mc/s (10 metres) to 50 mc/s (6 metres).

Ultra high frequencies are employed in television services, the B.B.C. service using 45 mc/s for vision and 41·5 mc/s for the sound accompaniment.

The continuous wave radiated into space in the way described can be robbed of its energy by any conductor it may pass on its travels, the energy lost to the wave appearing as current, and eventually heat, due to resistance-losses, in the conductor. If this latter happens to be an aerial-wire, the currents can be made audible by a suitable wireless receiving installation.

Modulating the Carrier-Wave. Neither music nor any other intelligible message can be conveyed by a continuous wave of constant amplitude; this wave really does no more than establish a link between transmitter and receiver, for which reason it is usually called a carrier-wave. If it is interrupted by being broken up into short and long periods of transmission, the dots and dashes of the Morse code can be sent; this is one form of radio telegraphy. For music or speech, something a little less drastic than complete interruption is required.

Taking the simplest case, let us suppose it is desired to make the continuous wave carry a single pure musical note, the 'waveform' of which is shown in Fig. 10b, drawn to the same scale of frequency as Fig. 10a. That is, many radio-frequency cycles occur in the time of one audio-frequency cycle. Complete interruption of the carrier being too drastic, nothing remains but *partial* interruption, which may be interpreted as a change in intensity. Fig. 10c shows the carrier-current at *a*, varied in amplitude at the frequency of the musical note at *b*; the complete combination is a radio-frequency current still, and can be radiated as such, but it will now carry with it in its variations of intensity the impress of the musical note that it is its duty to convey. The whole is called a *modulated carrier*, the note itself being referred to as 'the modulation.'



CARRIER-WAVES. *Fig. 10. Diagram illustrating how a continuous wave is modulated by a vibration of low-frequency. The unmodulated carrier is shown at (a), the low-frequency to be transmitted at (b), and the modulated carrier bearing the impress of (b) is given by the composite wave (c).*

When music or speech is being transmitted the form of the modulation is that of an extremely complex and irregular wave; but both in principle and in practice it is just as easy to modulate a carrier with the complex speech-currents from a microphone as with a current representing a single pure note.

Actually Fig. 10 shows far too few radio-frequency cycles to each audio-frequency cycle. A 1,000-cycle note on a 1,000-kc. carrier would have a thousand radio cycles to each audio cycle, instead of the dozen or so shown in the diagram. A better, though less readily intelligible, representation would result if the whole space between the dotted lines showing the envelope of the wave in Fig. 10c (p. 405) were shaded, implying a radio-frequency far too rapid to follow.

Frequency Bands. The variations in amplitude of the carrier caused by the addition of the modulation may be expressed in another way, which is of considerable importance in receiver design. Both mathematically and physically, these variations in amplitude are exactly equivalent to the addition of new, less powerful carrier-waves differing in frequency from the original one by the frequency of modulation. The importance of this lies in the fact that a carrier modulated with musical frequencies up to 8,000 cycles loses its definite single frequency and becomes a band of frequencies 16 kc. wide, centred on the frequency of the unmodulated carrier. Thus a station nominally transmitting on 1,000 kc. may actually occupy all frequencies from 992 to 1,008 kc., and care has to be taken in the receiver to shepherd the whole band, and not its centre only, through the set.

The Detector. Once in the set, the music brought by the carrier has to be made audible. Telephones alone cannot do this, for they will not respond to the radio-frequency component, so that from their point of view the current at any instant is zero, the positive current (above the line in Fig. 10c) always being exactly balanced out of the negative current (below the line). That the currents thus balancing are sometimes large (at P) and sometimes small (at Q) does not matter; the balance remains.

But if it were possible to lop off half the wave by inserting in the circuit some contrivance that allowed the positive currents to pass while stopping the negative currents, there would remain an average positive current rising and falling at the frequency of the modulation. This current would, in fact, follow the curve outlining the upper side of the modulation-envelope. The telephones would, therefore, reproduce the note originally superimposed on the carrier at the transmitting station.

The contrivance used to suppress half the wave in order to make the modulation audible is called a *detector*; sometimes it is a crystal, but a thermionic valve is nowadays more often used for this purpose.

Frequency Modulation. Another method of impressing musical frequencies on a carrier-wave, and one which is now finding extensive employment in U.S.A., is by arranging for the amplitude of the musical programme to control the frequency of the carrier-wave. In this way the loudness of the programme is represented by the change in frequency from the normal unmodulated value and the frequency of the musical programme is equal to the number of swings in carrier frequency which occur in unit time. Such a system is termed *Frequency Modulation* and it is usually used on the ultra-short waves of 30—50 mc/s. It is claimed that this method of modulation can be made to give greater freedom from noises due to static and electrical interference than the more usual amplitude modulated system with which we are familiar in this country. Frequency modulated receivers are noted in page 429.

LESSON FIVE

The Three-Electrode Valve

The process of detection, mentioned in outline at the end of Lesson 4, is the most complicated of all the duties that fall to the lot of a valve: we will therefore begin with simpler matters.

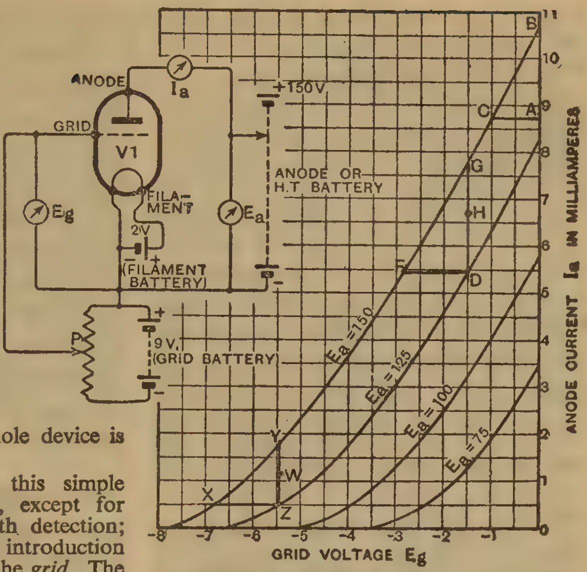
A valve for use in battery sets operates by virtue of its filament, a fine wire, which, when heated by the passage through it of a current, emits from its specially prepared surface a continuous supply of electrons. Filaments are rated to consume from ·06 to ·3 amps at 2 volts in sets using a 2-volt accumulator as low tension supply, or ·05 to ·15 amps at 1·4 volts in valves used in modern all-dry receivers, where the low tension supply is derived from a dry cell. In mains valves the electron emitting surface, usually a coated metal sheath, is heated by a fine copper wire placed within it. The sheath, or *cathode*, is electrically insulated from the heater, and in this fact lies the chief difference between battery and mains valves. They have similar characteristics and although the diagrams which follow will for the most part indicate battery valves this is only done for the sake of simplicity.

It must be remembered that the circuits apply equally well to both types of valves.

By the application of a positive voltage to another electrode within the glass or metal bulb these electrons can be attracted through the evacuated space to this second electrode, or *anode*. If a negative voltage is applied to the anode, the flow of electrons to it is stopped, *but not reversed*, because the anode, being neither hot nor specially prepared, does not emit electrons. Since the electrons, the movement of which constitutes a current, can pass through the space between the electrodes in one direction only, the whole device is called a *valve*.

Three-Electrode Valves. In this simple form the valve is little used, except for special purposes connected with detection; its real utility begins with the introduction of a third electrode, known as the *grid*. The grid consists of an open mesh of wire through which electrons bound for the anode have to pass; its function is to assist or retard, according to the voltages applied to it, the flight of electrons through the valve. Its action in this respect can be seen from the curves of Fig. 11, in which the current to the anode (I_a) is plotted vertically and the voltage applied to the grid (E_g) plotted horizontally. A curve is taken for each of several fixed voltages on the anode; these voltages (E_a) are marked against each curve.

The circuit-diagram inset shows how such curves are taken; a positive voltage, set at the right value by the aid of the voltmeter E_a, is applied to the anode of the valve. To provide continuous variation of grid-voltage there is connected across the 9-volt grid battery a potentiometer P, the moving arm of which is joined to the grid. A second voltmeter E_g records the voltage on the grid, and the current flowing to the anode for each successive setting of this is read off from the milliammeter I_a. It is specially to be noted that the voltages E_g and E_a are measured between grid or anode and the *negative* end of the filament. This convention allows valves requiring 6 volts for filament-heating to be compared with those only needing the 2 volts shown in Fig. 11. A number of new symbols are introduced in this diagram.



THREE-ELECTRODE VALVE. Fig. 11. Characteristic curves.

Grid Control. Looking at the curves separately, it will be seen that for any fixed anode voltage the anode current rises as the grid is made more positive. At $E_a = 150$, for example, I_a is 3·65 mA when $E_g = -4$, rising to 6·9 mA when $E_g = -2$. Making the grid less negative by 2 volts has allowed electrons representing an extra 3·25 mA to pass through it to the anode. The grid clearly exercises very effective control over the electron-stream, the numerical extent of this control being about 1·6 mA per volt for these particular conditions of operation. The control of grid over anode current is conventionally expressed in milliamps per volt (expressed as microamps per volt in U.S.A.) and is called the mutual conductance *g*.

The value of *g* depends on the voltages applied to the various electrodes; at $E_a = 75$, $I_a = 0{\cdot}15$ mA for $E_g = -3$, and 0·75 mA for $E_g = -2$. Here the mutual conductance is only 0·6 mA/v. For this, as for all valves, it is highest when the current is high; taking *g* from $E_g = -1$ to $E_g = 0$ at $E_a = 150$ the figure rises to 2.0 mA/v. (AB/AC). Since, as we shall see later, the valve amplifies by virtue of the control exercised by the grid over the electron stream, a high value of *g* implies high amplification, and is therefore much sought after.

The ratio AB/AC defines the average slope of the curve over the range CB; for that reason mutual conductance is often called *slope*, and one speaks of a valve with a large value of *g* as a 'high-slope valve.'

Other Valve Characteristics. If we draw a pair of lines GD, FD, as though to determine *g* over the range GF, but choosing D so that it falls on a curve relating to another anode voltage, we can extract some more useful information about the valve. GD shows the change in anode current that results when E_a is dropped from 150v. to 125v., leaving E_g unchanged. At D, $I_a = 5{\cdot}45$ mA, while at G, $I_a = 7{\cdot}8$ mA, a change of 2·35 mA for 25v. This corresponds to a resistance of 25/0.00235 = 10,600 Ω. This resistance is that which the valve would offer to an alternating voltage swinging the anode between the limits 125v. and 150v.; that is, having a peak value of 12½v. and being superimposed on a steady anode voltage (from the battery) of 137½v. (Point H). The resistance thus found is therefore called the 'anode A.C. resistance' or 'impedance' of the valve. (Symbol R_o.)

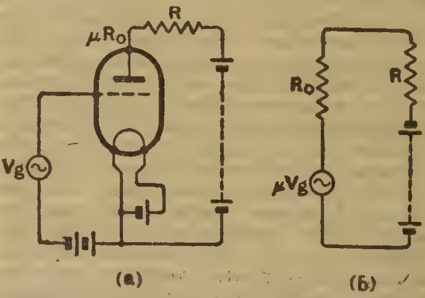
It is specially to be noted that R_o, like *g*, depends on the operating voltages; over the range YZ R_o turns out to be 25/0.00127 = 19,700Ω. Neither this value nor that previously found has any necessary relationship to the D.C. resistance of the valve, expressed as E_a/I_a; without altering E_a, I_a may be given almost any value by adjustment of E_g, each leading to a different value for the D.C. resistance. In practice one is not concerned with the D.C. resistance of a valve; it has only been mentioned here to draw the necessary distinction between it and the all-important resistance R_o to alternating currents.

The line FD on Fig. 11 has its significance, too; it represents the change in grid-voltage, in this case 1.37v., necessary to hold the anode current steady while altering the anode voltage by 25v. It is clear that the grid-voltage exerts 25/1.37 = 18.2 times as much influence on the anode current as does the anode voltage; this ratio is called the *amplification factor* μ of the valve. Unlike *g* and R_o μ is practically independent, *in a triode*, of the operating voltages. From XZ, for example, $\mu = 25/1{\cdot}35 = 18{\cdot}5$, which is practically the same value as found at FD.

The three properties of the valve, μ, *g*, and R_o, are interrelated thus: $g = \mu/R_o$. It follows, since μ does not vary, that changes in *g* with operating voltages are due to changes in R_o.

The Valve as Amplifier. We have seen that one volt applied to the grid of a valve has the same effect on anode current as μ volts applied to the anode. If, therefore, we apply to the grid an alternating voltage V_g, which swings the grid back and forth over a small range of voltages round a central point determined by the steady D.C. voltage E_g applied, we have in the anode circuit the equivalent of an alternating voltage μ times as great. It therefore becomes possible to replace the circuit of Fig. 12a, which shows a valve to whose grid a signal-voltage V_g is fed and in series with whose anode there is a resistance R, by the simplified circuit of Fig. 12b, which is very much more amenable to calculation.

The total alternating voltage across R and R_o is clearly μV_g; that across R will be the fraction $R/(R+R_o)$ of the whole. For V_g volts applied to the grid, therefore, we obtain $\mu R V_g/(R+R_o)$ volts from the anode, representing a voltage amplification of $\mu R/(R+R_o)$ times. This stage gain will approach the value μ as R is made greater and greater. We have the result therefore that the stage gain A of a triode with a resistive load is given by:



THREE-ELECTRODE VALVE. Fig. 12 (a). Simple amplifying stage; (b) circuit equivalent to (a), showing the anode circuit only, but containing the voltage μV_g due to the action of the grid.

$$A = \frac{\mu R}{R + R_o}$$

A little thought will show that the steady potential applied to the grid when the valve is used as an amplifier must equal at least half the peak to peak value of the signal superposed on it. This steady potential is known as grid bias. In old type sets this polarising voltage used to be obtained from dry cells but in mains sets and modern battery receivers the grid bias is derived in an interesting way from the high tension supply. Some details of this method are given in Lesson 8 (page 419), and, for battery receivers, Lesson 9 (page 421).

LESSON SIX

Radio-Frequency Amplification

The process of magnifying the radio-frequency voltage induced in an aerial when a carrier-wave strikes it is called *radio* or *high frequency amplification.*

Every receiver begins with a tuned circuit, since this provides both a certain selectivity and some magnification of the received voltage. In Fig. 13a the tuned circuit L_1C_1, coupled to the aerial coil which carries the aerial currents due to all transmitters within range, selects from the mixture and magnifies that which has the desired frequency (Lesson 2, p. 401). As the figure shows, the input voltage V_g to the valve V_1 is that developed across the variable tuning condenser C_1

From the formula for amplification $A = \frac{\mu R}{R + R_o}$ developed at the end of Lesson 5 (page 408), it would seem that high gain could be had by inserting a resistance R in the anode circuit of V_1, and allowing the signal to build up a voltage across it. Unfortunately, this simple scheme does not work, the reason being that from anode to earth there are several small condensers formed by the wiring, the electrodes of the valve, the terminals of the valve holder, and other such unconsidered trifles. The total of these *stray capacities*, including those due to the second valve V_2, would in a normal case amount to some 35 $\mu\mu$ F., and they are represented in Fig. 13a by the dotted condenser C_2.

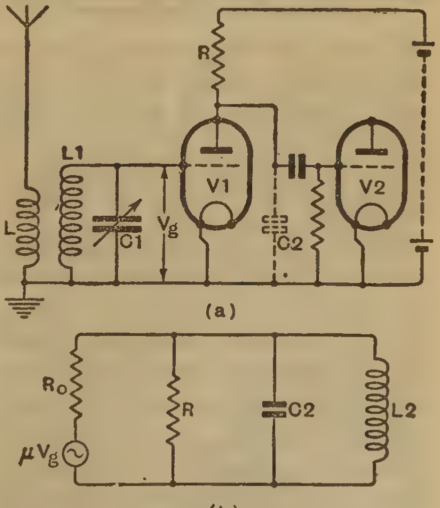
At $f = 1{,}000$ kc. ($\lambda = 300$ m.) the reactance of C_2 will be $2\pi fC = 4{,}600\Omega$. This path from anode to earth is effectively in parallel with R, since both run from anode of V_1 to a point of zero signal potential (batteries or earth); it is therefore impossible to build up an impedance greater than this 4,600 ohms in the anode circuit, and, in consequence, only very low amplification can be attained.

We have seen that if an inductance is placed in series with a capacity, as in Fig. 4 in Lesson 2 (page 400), the voltage across the one can be made, by correct tuning, to nullify exactly the voltage across the other, while the magnitude of the current through a resistance in series with them is unaffected by their presence. To currents to which they are tuned their joint impedance is, in fact, zero.

If the same coil and condenser are connected in parallel instead of in series, the current through one exactly neutralizes the current through the other, while the magnitude of the voltage across a resistance in parallel with them is unaffected by their presence. To currents to which they are tuned their joint impedance is, in fact, infinitely high.

Tuned Anode Circuit. Making use of this fact, we can connect a coil L_2, so chosen as to tune with the stray capacities C_2 of Fig. 13a, between anode and earth; this will wipe out C_2 as a possible path for the signals, leaving only R. The circuit resulting is given in skeleton form in Fig. 13b, and it will be seen that the amplification of the stage now becomes $\frac{\mu R}{R + R_o}$ which is the value we set out to obtain.

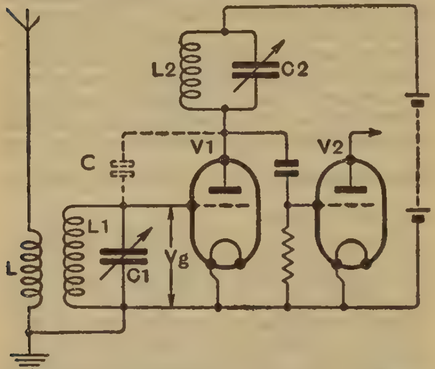
Since the coil is quite capable of carrying the steady anode current of the valve, we may proceed a step further and leave out R altogether, putting L_2 in its place. Further, since it would be awkward to have to readjust L_2 to compensate exactly for the stray capacities at every new frequency as the receiver was tuned from station to station, we make L_2 of just high enough inductance



R.F. AMPLIFICATION. Fig. 13. (a). Circuit for high-frequency amplification that fails owing to stray capacities C_2*; (b) equivalent circuit, showing* C_2 *balanced by an inductance* L_2*.*

to tune with the strays at the highest frequency to be received, and add a parallel variable condenser to augment the capacity when we want to tune to stations of lower frequency. This brings us to the circuit of Fig. 14—the *tuned anode* circuit.

According to theory, L_2C_2 is an infinite impedance to anode currents of the frequency to which it is tuned, so that the voltage across it will be μV_g. In practice, it will be less, because both L_2 and C_2 will inevitably have some resistance associated with them. Since the inductance is not a pure inductance, nor the condenser a pure capacity, their currents will no longer exactly balance, with the result that their joint impedance will no longer be infinitely high. To the frequency to which they are tuned their impedance will be L/Cr ohms, where r is the sum of the resistances in the two branches of the circuit.



TUNED ANODE CIRCUIT. Fig. 14. A practical form of Fig. 1 (b). This, in turn, fails owing to self-oscillation set up by the grid-anode capacity C. A screen-grid valve at V_1 remedies this.

A tuned circuit may therefore be regarded either as being constituted like Fig. 15a, where L and C are both considered resistanceless, and the resistance inherent in them in any practical case is supposed concentrated at r; or, alternatively, as being built up like Fig. 15b, where again L and C are free from resistance, but the whole is shunted by R. If the two circuits are identical, $R = L/Cr = (2\pi f L)^2/r = 2\pi f LQ$. The scheme at (*a*) is usually most convenient when considering currents flowing round the circuit (as arrow), since $I = E/r$ at resonance (series or *acceptor* circuit). That at (*b*) is handier when considering currents flowing through the circuit as a whole, since $I = E/R$ at resonance (parallel or *rejector* circuit). R is known as the *dynamic resistance* of the tuned circuit; r as its *equivalent series resistance.*

The circuit of Fig. 14 is thus identical with that of Fig. 13a (leaving out C_2), if by R in the latter we mean the dynamic resistance of the tuned circuit when tuned to the received frequency. At other frequencies L_2C_2 offers a comparatively low impedance, so that it helps the process of selection between stations begun by L_1C_1. The replacement of the original resistance by the tuned circuit has thus improved both amplification and selectivity.

If there were no resistance in the tuned circuit L_1C_1, a current set circulating in it would never die away, since neither L_1 nor C_1 would be absorbing any power. In practice, there is resistance, and currents do die away fairly quickly, thus allowing the voltage on the grid of V_1 to follow the fluctuations in aerial current due to the modulation of the received carrier. In the circuit of Fig. 14 there is a capacity C, due to their nearness, between anode and grid. Through C flows a portion of the amplified high-frequency currents on their way from anode to filament, L_1C_1 completing their path. These stray currents tend to build up the currents originally present, with the result that the inherent resistance of L_1C_1 is no longer able to damp out the currents in that circuit quickly enough to enable it to respond to the more rapid changes in aerial current due to modulation. Since the rapid changes correspond to modulation by high notes, this means that the high notes are being scraped off the carrier by the over-sharp tuning of L_1C_1. Slower changes due to low-note modulation will still, however, be followed. The music eventually issuing from the loud-speaker will therefore be ' woolly ' in character.

Checking Oscillation. If even more energy is fed back through C from anode to grid, a current once started in L_1C_1 will not die

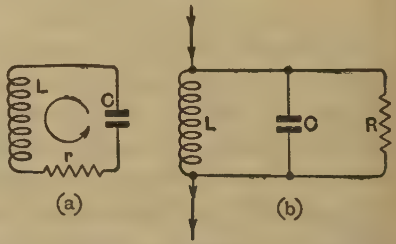
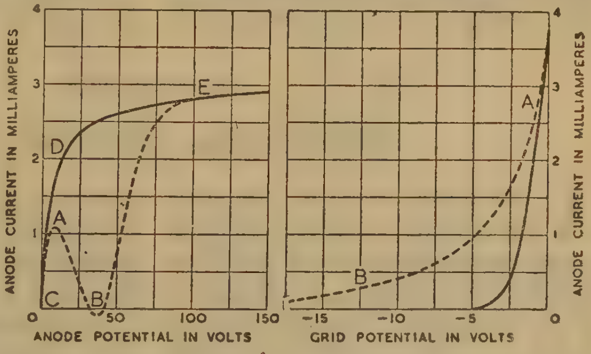


Fig. 15. Two ways of regarding the same tuned circuit: (a) with series resistance; (b) with parallel resistance. $R = \frac{L}{Cr}$

away at all, but will continue to mount until V_1 can increase it no more. This is the condition of *oscillation*, made manifest by shrieks and howls when tuning. With the circuit of Fig. 14 this generally happens.

To overcome this feed-back, the *screen-grid valve* is used. Between signal-grid and anode there is interposed a screen of fine-mesh gauze, which, in use, is connected to filament by a condenser offering negligible impedance to the high-frequency currents. Energy fed back from the anode is thus trapped by the screen and shunted harmlessly through this condenser to filament, without being allowed to pass through the grid circuit on the way; by using for V_1 a screen-grid valve the circuit of Fig. 14 immediately becomes completely stable.

This last statement is evidently only true if C is the sole route by which energy could pass back from anode to grid. If L_2 is so placed that its magnetic field can affect L_1, instability will still be present, as it will if the wires running to anode and grid are brought too close together. To avoid these other sources of feed-back, L_1 and L_2 are normally enclosed in screening-boxes to restrict their fields, while the anode of V_1 is taken out through the top of the bulb to keep the wires attached to it, whether inside or outside the valve, away from those attached to the grid.



(a) (b)

VALVE CHARACTERISTICS. Fig. 16(a). Anode current-anode voltage curve of tetrode (screen grid) valve, showing kink (dotted) of negative anode impedance, overcome by third grid, giving the pentode valve. Fig. 16(b). Anode current-grid voltage curve of variable-mu pentode valve (dotted). Solid curve is of non-variable-mu pentode valve.

The screen of the valve, if kept at earth-potential, would decrease the electron-flow to the anode so greatly that the amplification obtained would be very poor. It is therefore connected to a tapping (about 60v.) on the anode battery, giving it a voltage high enough to increase the electron-flow, while still being low enough to allow the anode to pull the bulk of the electrons to itself by virtue of its higher voltage (about 120v.).

Compared with a triode, a screen-grid valve has about the same value of mutual conductance, but its higher amplification factor, even though combined with a higher A.C. resistance, enables greater gain to be had from the stage as a whole.

The Pentode Valve. The introduction of the second grid into the triode, which gave us the screened-grid valve or tetrode, made possible for the first time stable high-gain R.F. amplification. But it was soon discovered that these tetrodes had one disadvantage as far as R.F. amplification was concerned. At low anode voltages the anode emits secondary electrons and as a consequence these valves develop a negative anode impedance as shown by the portion AB of the dotted curve in Fig. 16a. This limits the output of the valve.

There are two ways of overcoming this kink of negative resistance. One is by constructing the valve with a large space between screening grid and anode. This is the method employed in output tetrodes. The second is by introducing a third, earthed, grid between screening grid and anode, which gives us the pentode valve. Such construction is used in pentodes for R.F. amplification and power output purposes. The curve CDE in Fig. 16a is typical of the $I_a - E_a$ characteristics for a pentode and a tetrode with critically-spaced electrodes. Note the complete elimination of the kink of negative resistance.

Variable-Mu Valves. R.F. amplifiers may be called upon to amplify a weak signal to dimensions suitable for use by a detector or else they may be required to handle a very strong signal when the receiver in which the amplifier is built is tuned to the local station. Now an R.F. valve, whether pentode or tetrode, may have an amplification factor of several thousands which means that the valve can only operate satisfactorily on very small grid swings. If a large signal is applied then severe distortion inevitably results. In the early days of radio this difficulty was overcome by using an aerial potentiometer before the R.F. valve as a volume control, by means of which it was possible to reduce the signal from the local station to dimensions small enough for it to be handled safely by the R.F. amplifier.

In modern radio practice this difficulty has been neatly solved by the introduction of *variable-mu* R.F. valves. These are tetrodes or pentodes in which the spiral of wire which forms the control grid has been wound so that the pitch is wide one end and narrow at the other. As a consequence of this a small negative potential applied to the grid will completely stop electrons passing through the small meshes but not through the wide-mesh part. It takes a very large negative bias to stop the electrons passing through this part and so the $I_a - E_a$ curve for a variable-mu valve has the shape shown dotted in Fig. 16b (page 411). The solid curve applies to a non-variable-mu or straight tetrode or pentode.

The mutual conductance or slope of the variable-mu valve varies along the curve, being great at small negative bias values and small at large negative values of grid bias. Small signals applied when the grid bias has been adjusted to point A will receive great amplification as in normal straight R.F. valves, but if the valve is biased back to point B then the valve can quite happily accept a signal of 20–30 volts peak to peak value. Thus it is possible with such valves to control the amplification and the signal handling capacity simply by altering the grid bias. Hence the name variable-mu valve. These valves make the easiest and best kind of volume control possible.

LESSON SEVEN

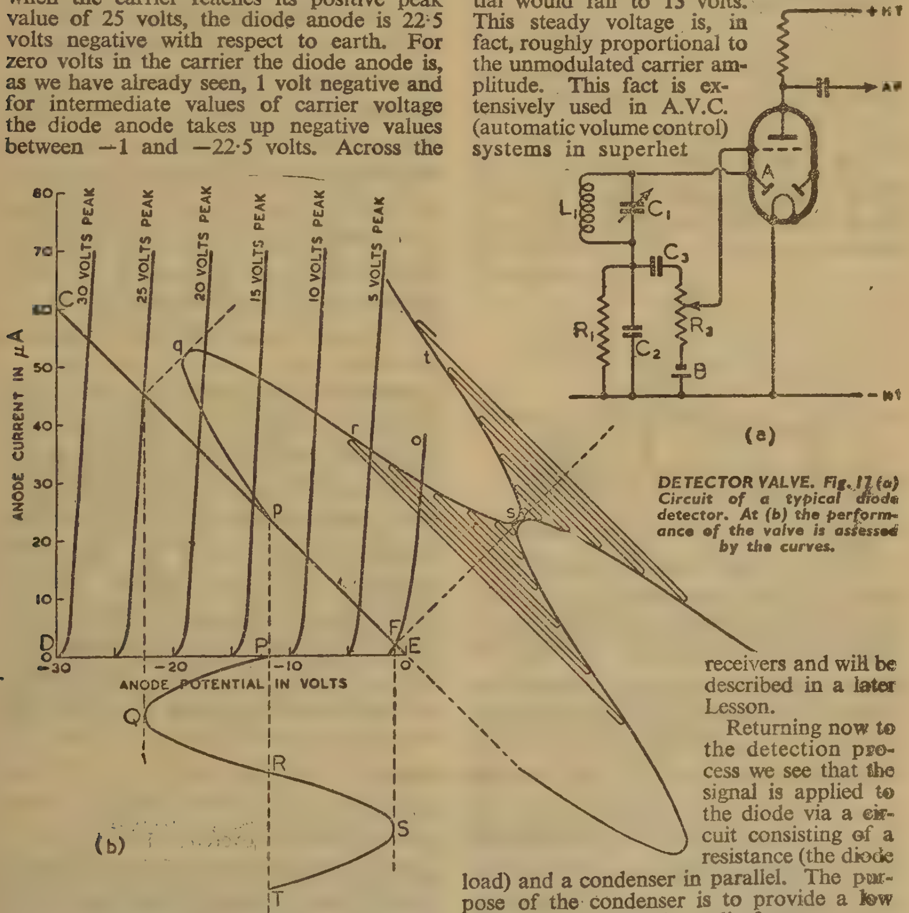
Principles of Detection

At the present time when the superheterodyne type of receiver (which we shall consider in detail in a later Lesson) has almost completely ousted all other types from the market, the diode type of detector, or demodulator, is the most popular. A typical circuit for such a detector is shown in Fig. 17a. Here two diodes can be seen, combined with a triode A.F. amplifier, all in a single glass bulb. This type of valve construction, where several simple valve types are combined within a single glass envelope, is typical of the complex varieties now available. The modulated radio-frequency signal appears across the tuned circuit L_1C_1 and is applied between the anode and filament of the diode A via the resistance R_1 and the condenser C_2. Detected audio-frequency voltages appear across R_1, and are applied via the coupling condenser C_3 and the volume control potentiometer R_2 to the grid of the triode A.F. amplifier. The coupling condenser C_3 is necessary to permit the potentiometer being connected to the grid bias battery B.

The Diode Detector. The method of operation of a diode detector is best understood by reference to Fig. 17b. Here the curves shown are $I_a - E_a$ characteristics for various values of A.C. voltages applied to the diode anode. The line CE is drawn so that DE/CD is equal to the value of the resistance R_1, known as the diode load resistance. Suppose the set in which this diode detector is incorporated is not tuned in to any station. Then no signal is supplied to the detector by the tuned circuit L_1C_1 and so the diode anode is effectively at earth or zero potential since it is joined to earth via the load resistance R_1.

In these conditions the voltage and current in our diode are represented by the point where the load line CE meets the characteristic for zero volts on the anode, i.e., point F. Examination of this point shows us that the diode anode current is $2\mu A$ and that the voltage on the anode is -1 volts. It may seem remarkable that the anode should take up a negative potential even when no signal is applied to the diode, but it must be remembered that the cathode is emitting electrons all the while and some of these are bound to reach the anode even though there is no positive potential on it to attract them there. The few electrons that do arrive, give rise to this small negative voltage.

We will now suppose that the receiver is tuned to a station. The immediate consequence is that a modulated R.F. signal appears across L_1C_1 and is applied to the diode. Now we saw in Lesson 4 how a carrier wave was modulated and we know from this lesson that the voltage now delivered by L_1C_1 appears as in Fig. 10c of Lesson 4. It is a radio-frequency wave varying in amplitude at audio-frequency. In Fig. 17b this wave is shown applied to the diode at point F. It is of 12·5 volts amplitude modulated fully at audio-frequency so that its value swings from zero to 25 volts negative and positive. The diagram shows that the negative swings of the carrier-wave produce no current in the diode but the positive swings do. We can see, in fact, that when the carrier reaches its positive peak value of 25 volts, the diode anode is 22·5 volts negative with respect to earth. For zero volts in the carrier the diode anode is, as we have already seen, 1 volt negative and for intermediate values of carrier voltage the diode anode takes up negative values between −1 and −22·5 volts. Across the diode load therefore we build up an accurate picture of the modulation wave-form as shown by the curve PQRST in the figure. Each of these points correspond to the points *pqrst* in the carrier-wave. A change in carrier volts of 25 thus produces a corresponding change of 21·5 volts across the diode load, this representing a detection efficiency of 86 per cent., which is actually rather poor for a diode.



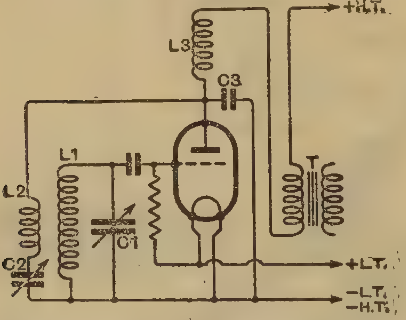
DETECTOR VALVE. *Fig. 17 (a) Circuit of a typical diode detector. At (b) the performance of the valve is assessed by the curves.*

Note that the audio-frequency output is a sine curve superposed on a steady potential of −11·5 volts. If the carrier-wave were to have a steady amplitude of 25 volts, this steady voltage would be −22·5 volts. If, for some reason, the carrier amplitude were to be reduced to 15 volts, this steady potential would fall to 13 volts. This steady voltage is, in fact, roughly proportional to the unmodulated carrier amplitude. This fact is extensively used in A.V.C. (automatic volume control) systems in superhet receivers and will be described in a later Lesson.

Returning now to the detection process we see that the signal is applied to the diode via a circuit consisting of a resistance (the diode load) and a condenser in parallel. The purpose of the condenser is to provide a low impedance path to the radio-frequency currents. It should, however, have a high impedance to audio-frequency currents, so that the value of this condenser is somewhat critical. In practice a value of ·0001 μF works well in conjunction with a load of 250,000 ohms.

Diode detectors work well in practice; they are practically impossible to overload and, in fact, give less distortion the greater the signal applied to them. With such detectors it is very easy to obtain voltages for A.V.C., A.F.C and other purposes. Diodes occupy little space and it is easy to combine two of them with a triode or a pentode in one glass envelope. These are the reasons why diode detectors are invariably used in modern superhet receivers. They have, however, the following disadvantages: they do not amplify in themselves and they offer a fairly low resistance to the tuned circuit which feeds them. That is to say they reduce its amplification and its selectivity, this being known as 'damping' the tuned circuit.

Leaky Grid Detection. Suppose we take an ordinary triode valve and we connect it up as a diode detector, using its grid as a diode anode. The true anode we will connect up as an A.F. amplifier as shown in Fig. 18. What will happen? The grid will function quite happily as a diode anode and will detect as explained above. Audio-frequency potentials corresponding to the modulation wave-form will appear on the grid and these will be impressed on the electron stream and so the valve amplifies the audio-frequencies. Such an arrangement sounds ideal, far superior to a normal diode which has an amplification factor or less than one. Where are the drawbacks? There are two.



GRID LEAK AND REACTION. Fig. 18. Triode grid-detector with reaction. Adjustment of condenser C2 neutralizes detector damping on L1 C1, sharpening tuning until circuit is thrown into oscillation.

We have seen how a diode detector develops a steady potential on which the audio-frequency output is superimposed and we have seen too how this voltage is dependent on the magnitude of the signal applied to the diode. In the case of the leaky grid detector this steady voltage has to play the part of grid bias for the amplifying process of the valve and it is easy to visualize that the steady potential may not be quite the right value for grid bias purposes. In fact only for one particular value of signal strength can this steady voltage be correct as grid bias. This fact limits very severely the range of signal strengths which may safely be applied to a leaky grid detector and if good results are wanted the only safe plan is to apply very small signals to the valve. Leaky grid detectors give their best results on small signals, a result quite the opposite to that for diode detectors.

The second drawback is that leaky grid detectors damp the tuned circuit which feeds them even more than diode detectors, due in this case to the presence of the anode-grid capacity. This difficulty can be overcome either by the use of a valve with a very low value of anode-grid capacity, such as a screened grid or R.F. pentode, or else by the use of reaction. This important addition to a leaky grid detector is largely responsible for the enormous popularity which this type of detector enjoyed some years ago and so we will devote a separate section to it.

Reaction. In connexion with radio-frequency amplification (Lesson 6, p. 411) attention was drawn to the evil effects of energy fed back from the anode circuit of a valve to its grid. The result was shown to be either an undue sharpening of tuning, or even actual self-oscillation, which amounts to the continuous generation of a high-frequency current. While such effects are unwanted in a high-frequency amplifier, where the resistance of the tuned circuits is, or should be, adjusted so that a received impulse dies away at a suitable rate, they could be made very useful in connexion with a detector valve where, as we have seen, the tuned circuit connected to its grid may be rather heavily damped by the detector.

This damping, equivalent to the introduction of extra resistance into the tuned circuit, reduces the current flowing and therefore the signal voltage across the tuning condenser. It can be overcome by arranging to feed the high-frequency currents in the anode circuit of the detector back to the grid, keeping them carefully under control to enable the effect to be properly regulated. One of the many possible circuits providing this *reaction* is given in Fig. 18.

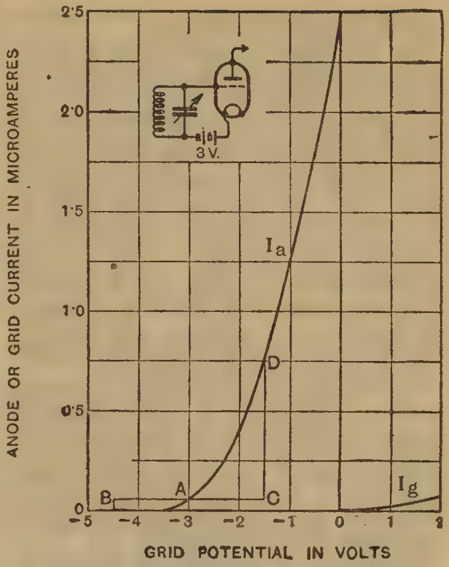
This shows an ordinary grid-detector in which the anode circuit contains a high-frequency choke L_3, the inductance of which is so chosen that it offers a low impedance to currents of speech-frequency and a high impedance to high-frequency currents. The former thus travel on through the audio-frequency transformer T; the latter pass to earth either through C_3 or the coil and condenser L_2C_2.

L_2 is coupled to L_1, with the result that the passage through it of high-frequency currents tends to build up the signal-voltage already present in L_1. Control of this effect is achieved by adjusting the reaction condenser C_2; this acts as a variable feed-impedance, and does not tune L_2 to the wave-length of the signal being received.

As C_2 is increased in capacity the signal being received gets louder and louder, the tuning of L_1C_1 becoming sharper the while. Ultimately the tuning becomes sharp enough to make the final music very low-pitched; reaction has then been pressed beyond its legitimate limit. The increase of sensitivity imparted to a receiver by the judicious use of reaction can be very great, especially if the detector, like that shown in Fig. 18, damps its grid circuit heavily. In consequence reaction has been very extensively used, especially in the simpler, low-priced sets.

Anode-Bend Detection. One of the disadvantages of diode detection is that as the tuned circuit that feeds it has to provide the voltage driving the grid-current, there is a certain loss of signal-voltage and flattening of tuning. This can largely be avoided by anode-bend rectification.

This depends on the curvature of the E_g–I_a characteristic instead of on the curvature of the E_g–I_g characteristic. Circuit and curve for anode-bend detection are given in Fig. 19, from which it will be seen that if a carrier of 1·5 v. amplitude is superimposed on the steady 3 v. bias at point A (I_a=0·06 mA) the anode current will swing in sympathy between zero and D (0·78 mA), giving a large increase in average current.



ANODE-BEND DETECTION. ***Fig. 19. Circuit and curve for an anode-bend detector.***

This audio-frequency current can, as usual, be converted into a voltage for transmission to the next valve by inserting a suitable impedance in the anode-circuit of the detector.

Unless the signal is too large, the region of grid-current (Fig. 19) is never entered at all with anode-bend detection; the tuned circuit therefore does not suffer damping from this cause. The capacity between anode and grid of the valve, however, will still feed back energy tending to suppress the voltage applied to the grid. To avoid this it is usual to choose a screen-grid valve for this function.

LESSON EIGHT

Output Stage in Modern Receivers

The loud speaker, connected in the anode circuit of the last, or *output* valve, requires power to operate it, since it has to do work in setting up sound-waves in the air. To provide this, power in reasonable quantities has to be taken from the anode battery; in consequence, output valves are built to consume a fairly high anode current.

To obtain maximum power from a valve it is necessary to use the correct anode and grid voltages, and in addition to use a loudspeaker of the correct impedance to give the valve its *optimum load.* Details of this, worked out by a geometrical construction from the valve-curves, are set forth in the instruction-slip issued with each valve. Leaving these calculations to the valve-makers, we will content ourselves with considering various types of output stage and their relative merits from the point of view of the designer and user of a receiver.

Triode Output Valves. The simplest output stage is provided by the triode valve. Its outstanding advantage is ease of handling and the certainty of good results that it offers even when mishandled a little.

For the amateur set-constructor there is often some difficulty in making sure that the speaker has the correct load for the valve to be used; in such a case the triode, which gives nearly full power over quite a wide range of loads, offers the safest choice. Since the ordinary 'cone' speaker (moving-iron type) offers very different impedances to speech-currents of different frequencies, it is quite impossible to make it conform to the optimum load condition, except at one particular frequency. This type of speaker is in consequence best served by a triode, the departure from optimum load at other frequencies being much less serious than with any other type of output stage.

To set against this there is the disadvantage that the triode requires a stronger signal to operate it than its usual competitor the pentode, while in addition it makes rather inefficient use of the anode-circuit power supplied to it, converting only some 15 to 20 per cent of it into audio-frequency power with which to drive the speaker.

The Pentode. Compared with the triode, the pentode has higher efficiency, since it converts over 40 per cent of the anode-circuit power supplied into speech-frequency output, requires a smaller signal-voltage at its grid for full power, but gives much more distortion if the speaker loads it wrongly. With a moving-coil speaker, the impedance of which does not vary greatly with frequency, the pentode is fairly satisfactory; with a moving-iron speaker it is better avoided except by the professional set-designer.

Improved results can be obtained with moving-iron and moving-coil loudspeakers by connecting a 'tone-control' circuit in parallel with the loudspeaker. This, in its simplest form, may consist only of a condenser in series with a resistance.

Since the reactance of the condenser falls with rising frequency, this has the effect of putting a resistance in parallel with the speaker for high notes, but not for low. This resistance, normally chosen to be about double the optimum load for the valve, prevents the anode-circuit load as a whole from running up to high values at the higher frequencies, and so prevents the development of excessively high signal-voltages across it. Over-emphasis and distortion of high notes are thus avoided.

Output Tetrodes. Towards the end of Lesson 6 it was mentioned that it was possible to eliminate the 'tetrode kink' by leaving a large space between anode and control grid. Modern radio technique makes extensive use of such valves for power output purposes, for these tetrodes are superior to normal pentodes in performance. They are slightly more efficient and give less distortion. It is common practice in these valves to direct the electron stream emitted by the cathode towards the anode by earthed deflecting plates mounted within the valve. Such valves are known as beam output tetrodes. In use these valves behave very similarly to pentodes: they have the same high impedance and require 'tone-controls' for best results.

Negative Feedback. We saw in Lesson 7 how the application of reaction, or regeneration, to a detector valve improved amplification but increased distortion by reducing the amplitude of the top notes. It seems logical to assume that if reaction is applied negatively (giving 'degeneration') then the opposite results will be obtained i.e. we shall reduce the amplification and distortion. This prediction is borne out in practice and the use of degenerative or negative feedback is becoming very popular in output stages, where it enables reproduction as distortionless as that from a triode to be obtained from a pentode or tetrode, whilst still retaining, of course, the most attractive attribute of the latter, namely the high efficiency. Some gain is lost, of course, but the reduction in all forms of distortion makes this loss well worthwhile.

There are countless ways of applying feedback: one of the simplest consists in omitting the usual bypass condenser from automatic grid bias systems; another is illustrated in Fig. 20. Here a potentiometer, consisting of the resistors R_1 and R_2, has been connected between anode and earth

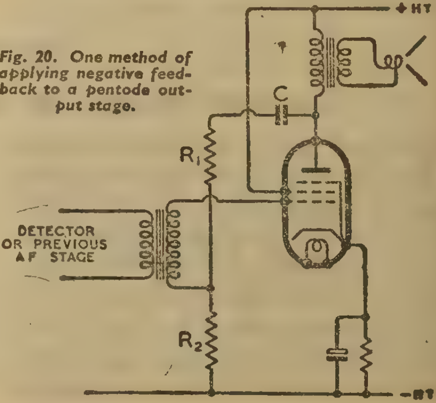


Fig. 20. One method of applying negative feedback to a pentode output stage.

so that a fraction of the output voltage is applied to the grid of the valve via the secondary winding of the intervalve transformer. It has been assumed here that the reactance of the condenser C is small compared with the value of $R_1 + R_2$.

Two-Valve Output Stages. If more power is required from the speaker than can be provided by a single valve, a second may be placed in parallel with the first, as in Fig. 21. This results in doubling both the steady anode-current and the signal-current driving the speaker, and so doubling the power.

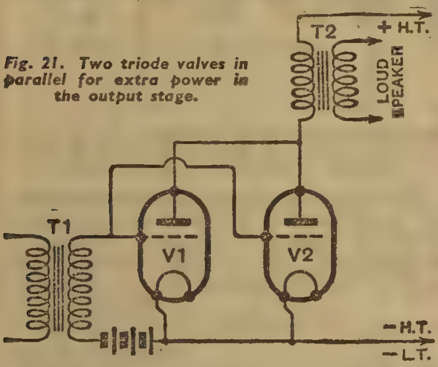


Fig. 21. Two triode valves in parallel for extra power in the output stage.

The output transformer T_2 is used in this and other cases because the impedance of the moving coil of the speaker, probably some 10 ohms or less, is too low to offer a satisfactory load for the valve. If T_2 had *n* times as many turns on primary as on secondary, the effective load of the primary will be n^2 times that of the coil itself.

An alternative method of connecting two output valves is shown in Fig. 22 where the valves are in *push-pull*. The signal-voltage is split between the two valves, so that if at any instant the grid of one is made more positive by the signal the other is made more negative. The resulting signal-currents in the anode circuits of the two valves are therefore in opposition, but by being made to flow in opposite directions through the centre-tapped primary of the output transformer their effect on the secondary is additive.

Since the steady anode-currents of the two valves are opposed, there is no permanent magnetization of the core of T_2, nor is there any signal-current flowing through the anode battery. The former allows of the use of a smaller transformer than would otherwise be possible, while the latter tends to prevent instability of the set as a whole. Hence a push-pull output stage is often preferred to two valves in parallel.

Q.P.P. (Quiescent Push-Pull). If about double the usual bias is applied to the grids of V_1, and V_2 in Fig 22, the anode-current becomes negligibly small until a signal arrives (compare Anode-bend Detection). The alternating signal-voltages make each grid in turn positive compared with its steady condition, so that each valve in turn sends a pulse of anode-current, in waveform like that of the applied signal-voltage, through T_2. The sum of the alternate pulses is an alternating current, so that a normal signal-voltage is induced in the secondary. Each valve deals with only one half-cycle of the signal.

The advantage of this *quiescent push-pull*, or Q.P.P., is that the anode-current taken from the battery is negligible in the absence of a signal, and is at any time only great enough to provide the required volume of sound in the speaker. In contrast, ordinary output valves take continuously a current large enough to cope with the strongest probable signal. But Q.P.P. has the disadvantage that unless the valves are exceptionally well matched, or their operating voltages carefully adjusted to provide artificial matching, much distortion is likely to arise.

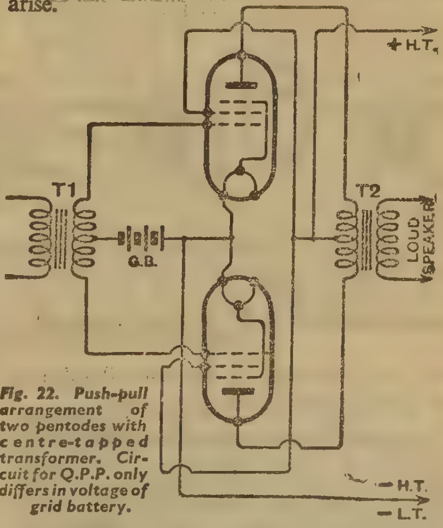
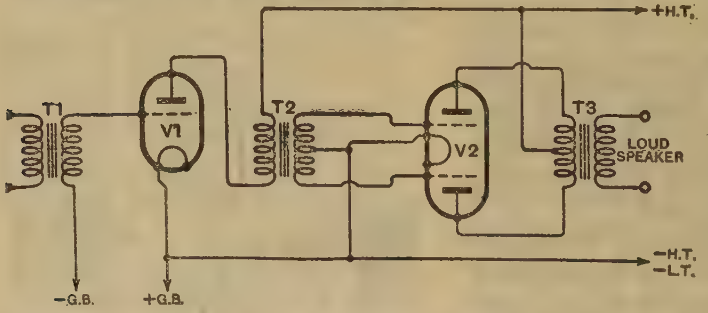


Fig. 22. Push-pull arrangement of two pentodes with centre-tapped transformer. Circuit for Q.P.P. only differs in voltage of grid battery.

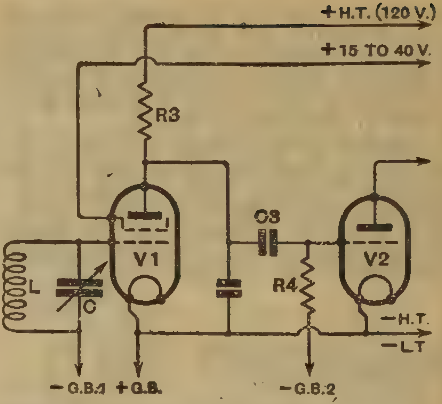
Class B Output. In any of the output circuits so far considered, grid-bias has been applied to make the grids of the valves sufficiently negative to ensure that they draw no current, even at the peaks of the signal. This is necessary because transformer secondaries and grid-leaks have been of such high impedance that the voltage across them would drop very rapidly if they were called upon to deliver any current, and the resulting distortion would be very evident.

It is clear that by suitable design of the transformer this limitation could be avoided, the output valves then being able to draw grid-current without appreciably affecting the voltage applied to them. An arrangement combining this conception with the alternate response of Q.P.P. is known as a *Class B output* stage, illustrated in Fig. 23. V_2 is a special Class B valve, consisting of two triodes in a single bulb. They are designed to take a very small standing anode current at zero bias, this current rising alternately in the two halves, as in Q.P.P., when the signal is applied. Quite a heavy grid-current flows, so that T_2 has to be designed, and V_1 chosen, to supply the necessary power. The *driver valve* V_1 is usually a small power valve consuming some 2 to 3 mA., while the *driver transformer* has a step-down ratio of about 2 : 1 (overall) instead of the step-up ratio preferred when wattless voltage is required to operate the next stage. The ratio chosen is such as to convert the load offered by the grid-circuits of the Class B valve to a value correct for the driver valve.



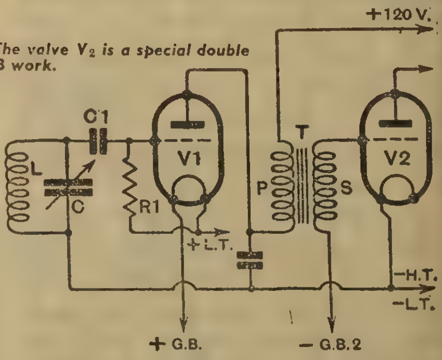
CLASS B CIRCUIT. *Fig. 23. A Class B output stage. The valve V_2 is a special double output valve designed for Class B work.*

This circuit is as economical as the Q.P.P. arrangement, with the advantage that, unlike Q.P.P., no special matching of the output valves is necessary. Since it enables a battery-driven receiver to combine a large output of sound with a very moderate consumption of anode current it was at one time a very popular output stage for battery receivers. In the U.S.A. it still enjoys a measure of popularity but has been for the most part abandoned in Great Britain in favour of the Q.P.P. system already discussed which gives superior reproduction.



RESISTANCE-CAPACITY COUPLING. *Fig. 24. Output valve coupled to detector (screen-grid anode bend) by resistance R3 to A.F. amplifier.*

Inter-Valve Couplings. In a modern receiver the output valve is generally driven directly from the detector, without intermediate amplification. The coupling between the detector and the output valve may be either a resistance, as in Fig. 24, a transformer as in Fig. 25, or a combination of the two. In Fig. 24 the audio-frequency voltages set up by the passage through R_3 of the rectified current in the anode circuit of V_1, a screen-grid valve used as



TRANSFORMER COUPLING. *Fig. 25. Triode-grid detector V1, coupled to output valve V2, a variation of Fig. 24.*

anode-bend detector, are passed on via the condenser C_3. A small speech-current will pass to earth through C_3 and R_4, the voltage across the latter only being applied to V_2. It is necessary, therefore, that even for the lowest frequencies the impedance of C_3 should be low compared with that of R_4; too small a capacity at C_3 will cause loss of bass. The effect of various values for C_3 and R_4 can be studied. Thus, if $C_3 = 0{\cdot}01\mu F$ and $R_4 = 1{\cdot}0 M\Omega$, the loss of bass will only amount to some 5 per cent at 50 cycles.

A triode grid-detector is shown in Fig. 25; the speech-frequency currents in its anode circuit in flowing through the primary winding P of the iron-cored low-frequency transformer T set up corresponding voltages across the secondary S. Since this normally contains from three to five times as many turns as P, there is a step-up of voltage of this order. This combination, with the addition of reaction, is probably the most popular of all, being simple, cheap, and very effective.

Fig. 26 illustrates the last two valves of a typical modern super-heterodyne receiver, namely the detector and output valves. The latter is a tetrode, which is fed from the anode of the triode section of a double-diode-triode by means of resistance-capacity coupling. The triode grid is connected to the slider of the volume control R_3, which is effectively in parallel with R_2, the diode load, as explained in Lesson 7.

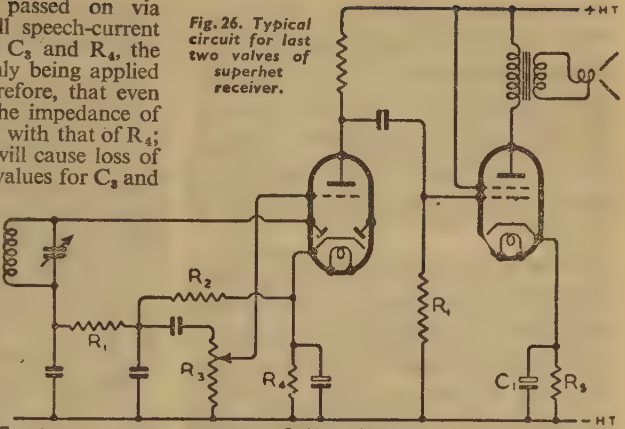


Fig. 26. Typical circuit for last two valves of superhet receiver.

Automatic Grid Bias in Mains Receivers. Note the resistors R_4 and R_5. These are provided to enable automatic grid bias to be obtained. Consider the output valve. This will probably consume an anode current of 40 mA and will require a grid bias of −8 volts. By Ohm's law the value of a resistor which will develop a voltage of 8 with a current of 40 mA flowing through it is 200 ohms. R_6 is therefore made 200 ohms. Now we do not want the alternating component of the anode current to flow through R_5 or else we shall have a varying grid bias so that the large electrolytic condenser C_1 is placed across R_5. If this has a capacity of $50\mu F$ then its reactance at all audio-frequencies will be considerably less than R_5, so that all the A.C. will flow through C_1.

Thus the valve cathode becomes a steady 8 volts positive with respect to earth so that as the valve grid is returned to earth via R_6 this becomes 8 volts negative with respect to cathode, which is what we want. The same argument applies to R_4. Note that the diode load R_2 is returned to the cathode of the double-diode-triode so that the bias on the diode anode is zero volts. This is necessary for successful detection.

LESSON NINE

Tuned Radio-Frequency Receivers

HAVING considered the three operations carried out in a 'straight' receiver, namely R.F. amplification, detection and audio-frequency power output, we are now in a position to investigate the circuit diagram of a complete receiver. Fig. 27 (p. 421) gives the complete circuit diagram of a three-valve two-waveband 'straight' battery-operated receiver of the type known as T.R.F.

Examination of this circuit shows that it comprises three pentodes, the first of which is a variable-mu valve functioning as an R.F. amplifier (the initials T.R.F. signify the presence of a tuned radio-frequency stage). The second valve, the detector, is an R.F. pentode of the 'straight' or non-variable-mu variety and the third is an audio-frequency power output pentode. We will now consider the receiver, stage by stage, in greater detail.

The R.F. Stage. The R.F. stage of the receiver includes all those parts of the circuit to the left of the line AB (Fig. 27). This receiver is designed to cover the long and medium wave ranges of 150–300 kc/s (1,000–2,000 metres) and 550–1,500 kc/s (200–550 metres) respectively, and, to achieve this, each tuned circuit is composed of two inductances, one of which (the larger) is shorted out by the wave change switch when medium-wave reception is wanted.

For example, in the first tuned circuit $L_3L_4C_2$, typical values of inductance and capacity being $L_3=157\mu H$, $L_4=2{,}000\mu H$ and $C_2=500\mu\mu F$ maximum, L_4 is shorted out by means of the switch S_2 when medium-wave reception is wanted, so that the total inductance in circuit is $157\mu H$ on medium waves and $2{,}157\mu H$ on long waves. L_1 is mounted close to L_3 and is usually on the same former. The same applies to L_2 and L_4. L_1 and L_2 serve to transfer the signal intercepted by the aerial to the first tuned circuit. S_1 and S_2 operate together, of course, both being closed for medium-wave reception. A small amount of amplification is usually obtained in this aerial transformer, but it seldom exceeds 10. The dotted line surrounding the transformer indicates that it is screened, i.e. mounted inside a metal box to prevent capacitative or magnetic interaction with other components in the receiver.

Notice that the inductance L_4 is not returned to earth but to a potentiometer R_7 via the R.F. filter R_1C_1, which has the function of preventing R.F. currents from straying into the audio-frequency section of the set so that, for successful operation, the reactance of C_1 must be much smaller than R_1. Suitable values are 1 megohm and 0·1 μF. The potentiometer R_7 forms the volume control of the receiver and applies a controllable negative bias to the grid of V_1 in a manner to be described later.

The screen of V_1 is fed from the 120 volt H.T. line via the resistance R_2, the value of this being chosen to give the desired value of screen volts, usually about 60. If, for example, the screen current is given in the data supplied by the valve manufacturers as ·5 mA for a screen voltage of 60, then it is immediately clear that R_2 must drop 60 volts when half a milliampere is flowing through it. Ohm's law then gives the value of R_2 as $60/{\cdot}005=120{,}000$ ohms. The size of the condenser C_3 must be such that it is a virtual short-circuit to currents at radio-frequency, for we saw in Lesson 6 that the screen needs to be earthed in order effectively to neutralise the anode grid capacity of V_1. A suitable value for C_3 is 0·1 μF.

The anode load of V_1 is the tuned circuit $L_5L_6C_5$ (also screened), the values of the components being the same as for $L_3L_4C_2$. The switch S_3 closes with S_2 and S_1 and in a commercial receiver these three, together with the filament on-off switch S_4, would be operated by a single control knob with three positions, thus, off, medium-wave reception and long-wave reception. The 0·1 μF condenser C_4 has a purpose similar to that of C_6: it effectively earths one end of the long-wave coil L_6 as far as R.F. currents are concerned yet allows the coil to be returned directly to the H.T. line.

This stage of R.F. amplification will probably amplify about 100 times. Assuming that the aerial transformer gives a voltage step up of 5 times (it will actually vary over the wave range covered) then the total gain realised in this receiver so far is 500 times.

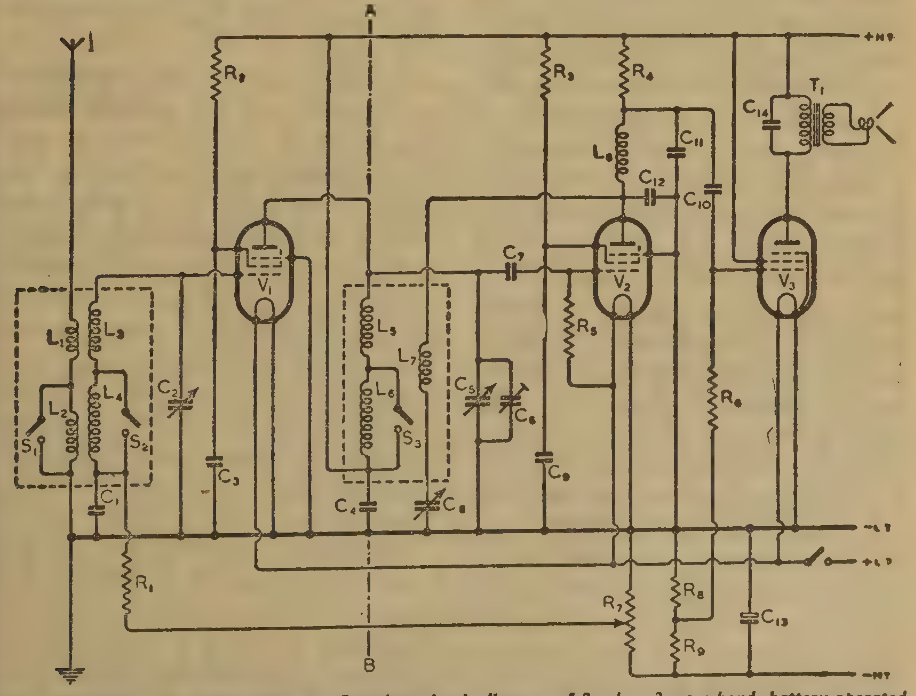
The Detector Stage. The use of a 'straight' R.F. pentode as a leaky grid detector is sound for, as we saw in Lesson 7, their low anode grid capacity means that the damping on the tuned circuit which feeds them is very small. This then gives its best performance with respect to voltage gain and selectivity. R_3 and C_6 are the screen feed components with similar values to those used in the R.F. stage; R_5 and C_7 are the grid leak and grid condenser respectively, suitable values being 1 megohm and ·0001 μF. L_8 is an R.F. choke, an inductance with a value of between ·1 and ·5H, which has a low reactance to A.F. currents but a high reactance to R.F. currents. It prevents R.F. currents from reaching the output stage and deflects them into the circuit L_7C_8, where their presence is beneficial, for this is the reaction circuit; the capacity of the reaction condenser C_8 controlling the degree of regeneration and hence the gain and selectivity of the detector stage. The A.F. voltage output of the stage appears across the anode load R_4, with a value probably of 75,000 ohms. C_{11} and C_{12} are additional R.F. filtering condensers.

The gain of the detector stage with no regeneration, i.e. with C_8 at minimum, will be about 60 times, but a loss will occur in the detection process, for broadcasts are not always 100 per cent. modulated. In fact this value is seldom reached, a good average being 30 per cent., so that we can say that the effective voltage gain of the detector stage is roughly 18 times, it being understood that reaction will increase this value perhaps 10 times before the quality of reproduction is hopeless, marred by the sideband cutting that reaction always causes.

The Output Stage. The A.F. output of the detector is fed immediately to the control grid of the output pentode V_3 via the coupling condenser C_{10} of ·01 μF capacity. Bias of −3·6 volts is applied to V_3 by means of the 1 megohm grid leak R_6. The moving-coil loud-speaker is connected in the anode circuit of V_3 by means of the usual matching transformer T_1, C_{14} having the purpose of limiting the rise in moving coil impedance at high audio-frequencies. If the moving coil has a resistance of 2 ohms, a likely value, and if the optimum load resistance of V_3 is 14,000 ohms, also a common value, then the ratio of T_1 for correct matching is $\sqrt{14{,}000/2}=84:1$ step down.

We now come to the automatic biasing arrangements by means of which the −9 volts, which is the maximum bias required by the R.F. valve, and the −3·6 volts for the output pentode are obtained without the use of additional dry cells from the main H.T. battery. The advantage of this system over the old is, of course, that the bias values obtained are always corrected automatically and there is no need to make adjustments as the main H.T. battery runs down. The total H.T. current of the set with a new H.T. battery is probably about 9 mA (6 mA for the output valve, 1 mA for V_2 and 2 mA for V_1 though the current taken by V_1 will depend on the setting of the volume control R_7).

If this total H.T. current is passed through a resistance of 1,000 ohms then we shall obtain 9 volts developed across it, which can be used for biasing V_1. It is convenient to make up the value of 1,000 ohms by using a 400 ohms resistor in series with a 600 ohms component, for the 3·6 volts developed across the 400 ohms resistance can be used, as shown in the figure, for biasing the output pentode. This is the method shown in the circuit diagram where R_8=400 and R_9=600 ohms. The voltage across R_8 is applied to the grid of V_3 and by means of the volume control potentio-



T.R.F. BATTERY RECEIVER. *Fig. 27. Complete circuit diagram of 3-valve, 2-wave-band, battery-operated 'straight' receiver with tuned radio-frequency stage.*

meter R_7 any value of bias between zero and -9 volts can be applied to the grid of V_1. As the H.T. current contains R.F. and A.F. components it is necessary to connect a large capacity (50μF is common) condenser across R_8 and R_9 in order to filter these from the steady D.C. component as discussed for indirectly heated valves in Lesson 8, (p. 419). Bias for both V_1 and V_3 are thus obtained without the use of additional dry cells. It should be noted that the 9 volts so obtained is subtracted from the main H.T. voltage; i.e. if a 120 volt H.T. battery is used only 111 volts will be available for the anodes.

If the grid bias of V_3 is $-3{\cdot}6$ volts then clearly a signal of 3·6 volts peak value is necessary fully to load it. Now if V_2 amplifies 18 times, V_1 100 times and the aerial transformer 5 times then the R.F. carrier input to the aerial-earth terminals necessary to give maximum output power is—

$$\frac{3{\cdot}6}{18 \times 100 \times 5} = {\cdot}0004 \text{ V}$$
$$= {\cdot}4 \text{ mV} = 400\ \mu\text{V}$$

A sensitivity of this order is quite normal for a receiver of this type, and the figure can be improved, of course, by the use of reaction. The receiver is sufficiently sensitive to give quite good reception from the stronger Continental stations.

LESSON TEN

Superheterodyne Receivers

We have mentioned before in this Course the popularity of the superheterodyne (or more simply 'superhet') type of receiver and we now propose to discuss their method of operation in some detail in order to find out why they have today almost completely supplanted the 'straight' type, a typical example of which is described in Lesson 9.

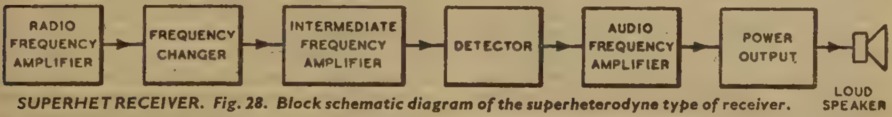
Briefly the theory of their method of operation is as follows. The wanted signal is 'mixed' with (or, to be scientifically correct, 'heterodyned by') the output from an oscillator situated within the receiver. This local oscillator may be regarded as a leaky grid detector with too much reaction applied, so that it generates continuous oscillations. One result of this mixing process is that a new carrier is generated, the frequency of which is the difference between the frequency of the original carrier and that of the local oscillator. Suppose the wanted station is transmitting on 1,000 kc/s and the local oscillator is generating on 1,465 kc/s. The new carrier generated as a consequence of the mixing will be on 1,465 − 1,000 = 465 kc/s. The difference term is known as the *Intermediate Frequency*, which we shall abbreviate for convenience to I.F.

In modern receivers the mixing and oscillating processes are nearly always carried out in a single valve known as a frequency changer. Some years ago it was customary to use two valves, one as 'mixer' and the other as oscillator, and this is still done today in the more expensive and elaborate types of receiver. Now the carrier generated at the intermediate frequency has impressed upon it the modulation of the wanted signal so that if we follow the frequency changer by a complete straight receiver tuned to the I.F. we shall hear the wanted programme as the output of the straight set.

The superhet receiver, then, changes the carrier frequency of every station it receives into a single, new, and generally lower, value known as the I.F., which is then amplified at radio-frequency, detected, and then amplified at audio-frequency as in straight receivers. All these processes are indicated in the block schematic diagram in Fig. 28, in which the frequency changer is drawn as a single block. In the cheaper type of superhets the R.F. stage preceding the frequency changer is omitted. All the remaining processes are frequently carried out by only three multiple valves!

Advantages of Superhet Principle. All this sounds very complicated and a very natural question is, what are the advantages of frequency changing? The answer is that it is a comparatively simple matter to design an R.F. amplifier to give high amplification, together with high selectivity, provided it has only to work at one carrier frequency. If it has to cover a wide frequency range as in straight receivers then its performance is upset and results are poorer in consequence. Also the amplification of an R.F. amplifier is proportional to the inductance of the tuned circuits in it. Consequently a high value of inductance, and hence a low value of radio-frequency, are desirable in order to achieve high gain. For these reasons it is advantageous to change the carrier frequencies to a lower value. At 465 kc/s, for example, a single R.F. pentode can easily amplify 200 times, but at 12 mc/s it is doubtful if a stage gain of more than 10 times can be secured. At one time the favourite I.F. was 110 kc/s but in modern sets 465 kc/s is used. The I.F. amplifier can be made as complicated as we wish without adding to the complexity of the receiver controls.

We will now consider the complete circuit diagram of an up-to-date superhet receiver for use on A.C. mains. It is given in Fig. 29, (p. 424) and at first sight appears rather terrifying but if taken stage by stage will be found rather simple. It represents a 3-wave-band, 4-valve (excluding rectifier) receiver.


RADIO FREQUENCY AMPLIFIER
FREQUENCY CHANGER
INTERMEDIATE FREQUENCY AMPLIFIER
DETECTOR
AUDIO FREQUENCY AMPLIFIER
POWER OUTPUT
LOUD SPEAKER

SUPERHET RECEIVER. Fig. 28. Block schematic diagram of the superheterodyne type of receiver.

The Frequency Changer. To the left of the line AB in Fig. 29 is the frequency changer, a multiple valve known as a triode-heptode. The right-hand side of this valve is a triode connected up as a leaky grid detector but with a fixed reaction condenser of such a value that the valve is oscillating all the time. The anode circuit of this triode is tuned and not the grid circuit, as is customary in leaky grid circuits for detection purposes. The left-hand side of this valve, the mixer section, may be considered as an R.F. pentode with two additional grids, one of which is bonded internally to the oscillator grid and so impresses the oscillator frequency on the electron stream of the valve, thus giving rise to the mixing process. The second additional grid is internally connected to the normal screening grid of the R.F. pentode and serves to prevent interaction between the oscillator and signal-frequency circuits. The signal frequency circuits which precede the frequency changer are similar to those preceding the R.F. valve in the straight set of the last Lesson, except that this set works over three wavebands, the additional short waveband being from 16·7 to 50 metres (6–18 mc/s) and so the waveband switching is correspondingly more complicated.

The receiver being described actually employs push-button control of wave-band switching as indicated in the diagram, which shows the medium-wave button pressed. The intermediate frequency of this set is 465 kc/s, which means that at all settings of the tuning control (the set employs ganged tuning condensers, of course, as in all modern sets) the oscillator frequency must be 465 kc/s higher than the signal frequency. As the receiver tunes from 150–300 kc/s, 550–1,500 kc/s and 6–18, mc/s the oscillator frequency ranges are clearly 615–765 kc/s, 1015–1,965 kc/s and 6,465–18,465 kc/s and at every setting of the tuning control the oscillator frequency must be just 465 kc/s higher than the signal frequency. This is known as 'tracking' and is achieved by means of the fixed condensers C_{10}, C_{11}, C_{12}, C_{14} and C_{15} which are carefully adjusted in value, as are also the oscillator tuning inductances L_{11}, L_{12} and L_{13} so that this desirable result is secured.

Notice that the control grid of the frequency changer, which is specially wound to give the valve a variable-mu characteristic, is not returned to earth but to the A.V.C. line. This is a source of variable negative grid bias and its derivation will be discussed later. The amplification of this frequency changer stage is a maximum when the A.V.C. line gives zero bias, and is about 50 times. It should be noted, however, that the automatic biasing arrangement R_3C_8 in the cathode lead of the frequency changer gives a steady negative bias of about 3 volts even when the A.V.C. line gives zero, so that this value is the minimum bias the valve receives.

The I.F. Amplifier. Between the lines AB and BC is a variable-mu R.F. pentode functioning as an I.F. amplifier. This part of the circuit is perfectly straightforward. Between V_1 and V_2, and V_2 and V_3 are the I.F. transformers T_1 and T_2 These consist of two identical tuned windings which are both alined at the correct intermediate frequency by the manufacturers at the factory. As the inductance of each winding is about 800μH, it will be appreciated that considerable stage gain is possible by using them.

In fact these transformers are the very heart of a superhet receiver for they are almost entirely responsible for its performance with respect to voltage gain and selectivity, and everyone who has handled a superheterodyne receiver will know that their performance in these two respects is a considerable advance on that of a straight receiver. Notice that the screen of this pentode is returned directly to the H.T. line. The stage gain of the I.F. amplifier is greater than any other stage of the receiver and amounts to about 200 times. A similar biasing arrangement exists for this valve as for V_1: there is a standing bias of -3 volts provided by the automatic system R_8C_{18} and the grid of the valve is returned to the A.V.C. line.

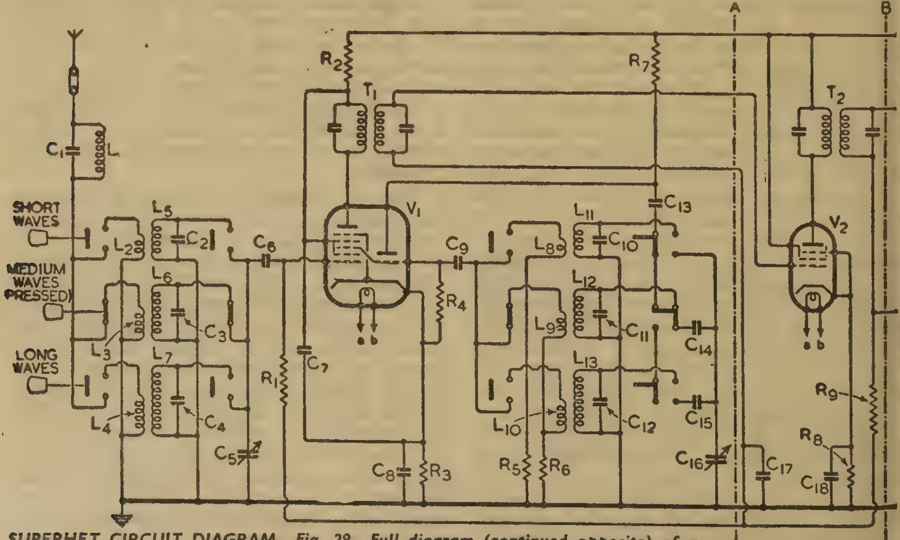
The Detector Stage. A diode detector and a triode A.F. amplifier are housed within the bulb of V_3 and the associated components are between the lines BC and CD. The diode detector circuit is quite normal. $R_{10}C_{19}C_{20}$ form an R.F. filter; R_{11} is the diode load resistance and R_{12} is the volume control potentiometer in the grid circuit of the triode A.F. amplifier. The negative D.C. potential developed by the detector is used, as we have seen, as bias for V_1 and V_2, the network R_9C_{17} having the function of ironing out A.F. modulation frequencies from this source of bias.

The triode functions as a resistance-capacity-coupled amplifier and is provided with the usual automatic biasing arrangement. As the valve consumes about 2 mA and a bias of -1 volt is desirable the bias resistor needs to be 500 ohms. The stage gain of the triode is probably about 20 times, so that, assuming 30 per cent. average modulation depth, the effective amplification from V_3 is about 6 times.

The Output Stage. The output stage, situated between CD and DE, is particularly simple. The speech coil of the loud-speaker is connected via the usual matching transformer T_3 to the anode circuit of the output tetrode and $R_{19}C_{26}$ connected between the anode and earth is the tone control designed to keep the effective speech coil impedance constant at the higher audio-frequencies. Notice that R_{19} is variable so that the listener can vary the degree of 'top cut' in the reproduction. The moving coil loud-speaker has an energized magnet. A normal output tetrode of the type used in this receiver needs a grid bias of about -8 volts and the anode and screen currents total 40 mA if the H.T. supply is 250 volts. The automatic bias resistor has therefore to be $8/\cdot04=200$ ohms. The maximum peak A.F. signal acceptable to this valve is 8 volts but 4 volts will give sufficient output for normal requirements. The total amplification of the receiver previous to the output valve is—

$$5\text{ (in aerial transformer)} \times 50\,(V_1) \times 200\,(V_2) \times 6\,(V_3) = 300{,}000$$

so that the aerial input necessary to give an adequate output listening level is only 13/1,000,000 or 13 μV. This is a very small



SUPERHET CIRCUIT DIAGRAM. Fig. 29. Full diagram (continued opposite) of a modern 3-wave-band, 4-valve (plus rectifier) mains-operated superhet receiver. Left of A B is the frequency changer. Between A B and B C is the intermediate frequency amplifier. Press button wave-change switching is provided.

voltage, which means that the receiver is very sensitive indeed, much more so than the straight receiver described in the last Lesson.

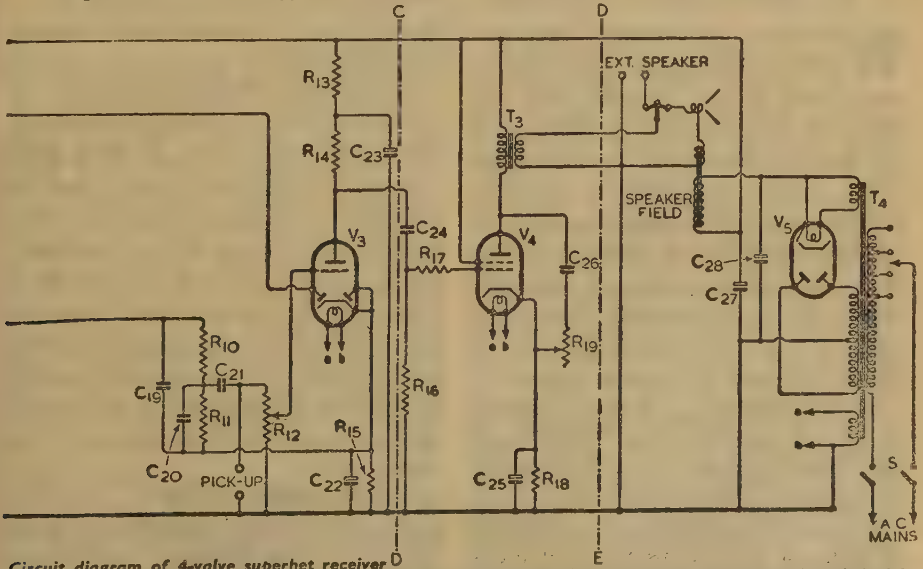
Power Supply. The small section of the receiver which is left to discuss, that to the right of the line DE, is known as the power pack and its purpose is to provide H.T., L.T. and current for energizing the loudspeaker. The H.T. supply is about 60 mA at 250 volts (D.C. of course); the L.T. is about 5 amps. at 4 volts (A.C.) and the loudspeaker will require 60 mA at 100 volts.

The manner in which these are obtained is as follows. The A.C. mains are connected, via the on-off switch S, to the primary of the transformer T$_4$, which has three secondary windings. One of these provides A.C. at 5 amps and 4 volts for the heaters of the valves V$_1$ to V$_4$. A second winding provides 4 volts at a smaller current (about 1.5 amps.) for the heater of the single rectifying valve V$_5$ in the power pack. The third, centre-tapped, winding provides about 700 volts, i.e. 350 across each half. This winding is connected to the anodes of the double-diode V$_5$.

Now current can only flow in one direction in a valve, namely from anode to cathode and it is clear therefore that the cathode of this valve becomes effectively the positive terminal of our H.T. battery. It is a peculiar H.T. battery, however, for it supplies not steady D.C. but pulsating current. Before it can be used in a receiver, this current must be smoothed. Now we have already seen how inductances resist changes in voltage applied to them, how a current takes time to reach its full value in an inductance. If therefore we pass this pulsating current through an inductance—the field winding of the loudspeaker is generally used—then we shall obtain a measure of smoothing. By adding the large condensers C$_{27}$ and C$_{28}$ even more smoothing is obtained, for these will charge up on voltage peaks and discharge on troughs so exerting a powerful levelling effect.

Even this, however, does not eliminate the last traces of ripple from the H.T. supply and a slight hum is audible in the loudspeaker as a consequence. These final traces can be eliminated by connecting in series with the speech coil a small winding which injects just sufficient out-of-phase ripple from the smoothing inductance to cancel that already present. The smoothed supply is finally 60 mA at 350 volts, sufficient to provide the energizing power for the loudspeaker and leaving 60 mA at 250 volts for the receiver proper.

Performance of the Receiver. The amplification of the receiver is, as we have seen, very considerable and is sufficient to enable almost any worth-while signal to be well



Circuit diagram of 4-valve superhet receiver continued. Between B C and C D is the detector stage. In V3 are included a diode detector and a triode A.F. amplifier. The output stage between lines C D and D E includes a tetrode V4 and a tone control, R19 C26.

received. Mere sensitivity by itself, however, is useless. Selectivity sufficient to enable the wanted signal to be obtained free from interference by stations on neighbouring frequencies is also a necessity and in this respect, too, the superhet type of receiver is outstanding. The receiver described above has an effective band-width of less than 9 kc/s. As the frequency separation of the many stations on the long and medium wavebands is 9 kc/s, this set is clearly easily capable of separating them. This is not true of the straight set.

Anti-fading Measures. Let us now discuss the performance of the *automatic volume control* (A.V.C.) circuit. Suppose the receiver is tuned to the local station. There is an immediate tendency for V_1 and V_2 to develop their maximum amplification and consequently to supply a very large signal to the diode detector. One result of this, of course, is that the detector delivers a corresponding high negative voltage to the A.V.C. line, so biasing back V_1 and V_2 and reducing their amplification. Equilibrium finally results with V_1 and V_2 heavily biased back. If a weak station is tuned in, the bias developed by V_3 is small and so V_1 and V_2 amplify considerably.

The result of all this is that the receiver tends to give roughly equal audio-frequency output no matter what the signal strength applied between the aerial-earth terminals, i.e. all stations are received at approximately the same output. Also—and this is the main purpose of A.V.C.—should the signal strength of a station vary for any reason at all (due, say, to changes in atmospheric conditions or even by removal of the aerial lead!) the amplification of the A.V.C. controlled valves will change so as to keep the audio output substantially the same. To some extent therefore the set can combat that bugbear of short- and medium-wave reception, fading.

Unfortunately it cannot eliminate the horrid distortion that often accompanies fading. For really successful A.V.C. three or four controlled valves are necessary though the conventional 4-valve superhet with its two controlled valves can give a very useful performance.

LESSON 11

Portable, Universal and other Receivers

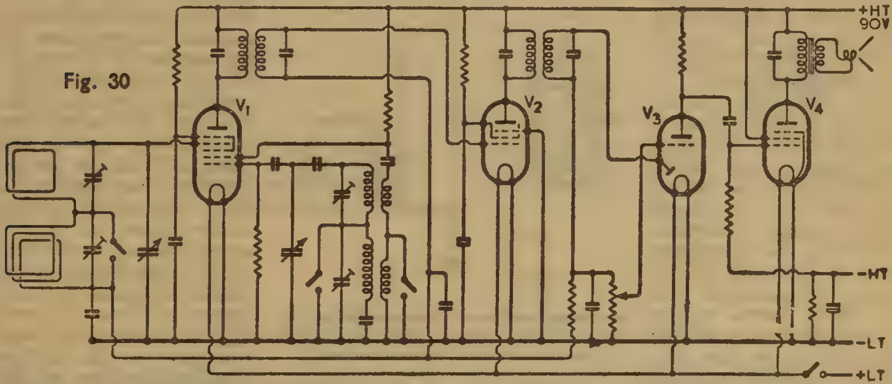
We have so far considered only two representative types of radio receiver, a battery-operated T.R.F. and a mains-driven all-wave superhet, both designed for use with an open aerial. The reader will easily be able to visualise the corresponding circuits for a mains-driven T.R.F. receiver, and a battery superhet, though in this connexion it is interesting to note that there is no battery equivalent to the mains triode-heptode frequency changer. Most battery superhets use a simpler type of frequency changer, the heptode or pentagrid, which is best regarded as a triode valve (the oscillator) surrounded by the electrode assembly of an S.G. valve. V_1 in Fig. 30 is a heptode frequency changer.

Portable Receivers. The circuit diagram of Fig. 30 is particularly interesting. It represents a modern 4-valve 'all-dry' portable battery superhet, i.e. it is a 4-valve battery-driven superhet using valves with 1·4 volt filaments energized from dry cells. The circuit is reproduced here as an example of the use of frame aerials, the aerial in this case being a winding wound on the outside or the back of the cabinet, and of heptode frequency changers.

Frame Aerials. A frame aerial may be regarded as a tuning coil of dimensions large enough for it to be capable of intercepting radio waves and producing quite good R.F. voltages across its ends. As it is by no means as large as an open aerial its pick-up is small but its amplification (Q value) is usually very high so that the net result is that a frame aerial is not very much inferior in performance to an open aerial followed by a normal tuned circuit. It is a little difficult to gang a frame aerial with an oscillator circuit but with care a satisfactory performance can be obtained. One great advantage of frame aerials is that they are markedly directional and so can be used to eliminate interfering signals if these are not arriving from the same direction as the wanted signal.

Heptode Frequency Changers. The action of this type of frequency changer is more or less obvious from the symbol which represents it. The first two grids, those nearest the filament, behave as control grid and anode of a triode oscillator. As the effects of these two electrodes on the electron stream of the valve are mutually destructive, their potentials being 180° out of phase, the anode is usually made as small as possible so that the grid exerts most effect. The rest of the valve behaves as the left-hand side of the triode heptode already discussed. The circuit diagram of Fig. 30 should now be quite clear. To make the set truly portable, both L.T. and H.T. are supplied from a single block of cells, and as the 1·4 volt valves are of very small dimensions, this circuit lends itself admirably to the construction of receivers of very small overall size, yet with a very useful performance.

Fig. 30



PORTABLE RECEIVER. *Fig. 30. Complete circuit diagram of a 4-valve, 2-wave-band 'all dry' portable battery operated superhet receiver. V_1 is a heptode frequency changer.*

D.C. Mains Receivers. Many areas in this country are still served by direct current supply mains instead of the more usual alternating current. The design of receivers for use on this type of mains supply presents many interesting problems. As the voltage is usually about 200 or 250, the mains can be used directly as H.T. supply in D.C. mains receivers, no rectification being necessary as in A.C. mains sets; but a certain amount of smoothing by means of iron-cored chokes and high-capacity condensers is still necessary to eliminate the hum in the loud-speaker which would be caused in the absence of smoothing circuits by the audio-frequency 'ripple' often present on D.C. mains.

The chief difficulty in the design of a D.C. mains receiver is the provision of L.T. supply. On first thoughts it might appear possible to use normal indirectly heated valves of the type used in A.C. mains sets, which consume, let us say, 1 amp. at 4 volts each. In a four-valve receiver, using such valves connected in series, a supply of 1 amp. at 16 volts is necessary. The only way to obtain this from a D.C. supply, on which transformers obviously cannot be used, is to connect the valves (already in series) in series with a suitable resistance across the supply mains. If the mains supply is 250 volts, the resistance needs to drop 250 − 16 = 234 volts at 1 amp., i.e., should be 234 ohms in value. It should also be capable of dissipating safely 234 watts! Such a resistance would be very costly and also very bulky and the whole arrangement is clearly uneconomical as we are deliberately throwing away 234 watts for the sake of obtaining 16. Economy is clearly only possible by using high voltage, low current heaters. Battery valves cannot be used for their low consumption filaments would give too much hum due to the ripple.

In order to provide a more satisfactory solution to this problem manufacturers introduced some years ago the so-called 'universal' or 'D.C. mains' valves, which are of the indirectly heated type with heaters usually consuming ·2 or ·25 amps., the voltage rating depending on the valve type, being about 13 volts for an R.F. pentode and 26 volts for an output pentode. In a four-valve receiver using these valves the heater supply will probably amount to 65 volts at ·2 amps. Most of the remaining 185 volts (we are still assuming 250 volt mains) can be dissipated either in energizing the field of a moving coil loud-speaker built to take the 200 milliamps. required by the heaters, or in a special type of lamp known as a barretter, which has the useful property, due to its enormous length of filament, of taking a more or less constant current irrespective of voltage fluctuations. A constant current device such as this is a useful feature in a D.C. mains set.

One annoying feature of D.C. mains receivers is that the metal chassis, which is usually connected to the negative side of the H.T. supply, is necessarily joined also to the negative side of the mains supply. If the positive side of the mains is earthed at the power station (which often occurs) then the chassis of the receiver becomes 250 volts negative with respect to earth, so that anyone coming in contact with the chassis itself, or anything connected to it, such as the set screws of control knobs, is liable to receive a substantial shock.

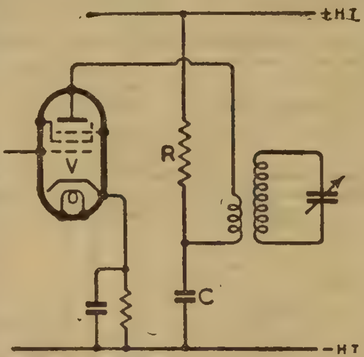


Fig. 31. Method of decoupling an R.F. pentode to prevent 'motor-boating.'

It is also clear that the chassis of a D.C. mains receiver cannot be directly earthed, for the mains supply may be short-circuited by so doing. They are generally earthed, therefore, via a condenser able to withstand the full mains voltage safely. Also the aerial should not be in metallic connexion with the chassis or this, too, may be a means of giving shocks to unsuspecting owners. To avoid this possibility the aerial coupling coils are generally returned, not to the chassis as usual, but to the earth connexion.

A.C.–D.C. Receivers. Much of what has been said of D.C. mains receivers above, applies with equal force to those receivers designed to work from D.C. or A.C. mains without alteration. These A.C.–D.C. models are best regarded as D.C. mains sets with the addition of a single-diode rectifier (half-wave) which behaves as a resistance when the set is in use on D.C. mains. The same components are used for smoothing on both types of mains supply. Needless to say the receiver will only work on D.C. mains when the mains plug is inserted in its socket the right way round.

Decoupling. In Lesson 8 we noted the beneficial effects of voltage feedback, in which a small percentage of the output voltage of a valve is fed back so as to be 180° out of a phase with the signal voltage in an earlier stage. Now it sometimes happens that two or more valves have a resistance in their common H.T. supply: this may be the resistance of a choke in an A.C. or D.C. mains receiver, or that of a partially exhausted H.T. battery in a battery receiver. This gives positive feedback, the consequences of which are roughly the opposite of those of negative feedback and consist usually of an increase in distortion and frequently instability, i.e. howling at an audio-frequency, increased hum or 'motor-boating' (oscillation at a few cycles per second).

Decoupling is a means of overcoming this difficulty, and consists of diverting audio-frequency currents through a large-capacity condenser and so preventing them from passing through the resistance in the common H.T. supply. Fig. 31 illustrates a decoupling circuit. The reactance of C should be small compared with the value of R at the lowest frequency required to be amplified in V. For audio-frequencies 20,000 ohms and 4μF work well; while for radio-frequencies 10,000 ohms and ·1μF are common values. R_{13} and C_{23} are decoupling components in the audio-frequency section of the super-heterodyne receiver illustrated in Fig. 29 of Lesson 10. It is not necessary always to decouple the anode circuit of all valves (it is never done with output valves) but it is always advisable when a receiver or amplifier displays a tendency to instability. No decoupling was included in the circuit diagram of the straight set of Lesson 9.

Tuning Indicators. The A.V.C. line of a receiver carries a voltage proportional to the signal strength of the station to which it is tuned. This voltage can be used as an indication of correct tuning, since it rises to a maximum value at the correct tuning point. It will be agreed that some sort of artificial aid to correct tuning is sorely needed, for modern superhets are so selective that even slight mistuning results in unpleasant distortion. A convenient means of rendering the A.V.C. voltage visible is by the use of a 'magic eye,' which is a small cathode ray tube (*see* next Lesson) in which the area of fluorescence on the target is controlled by the voltage on a deflecting electrode. These tuning indicators embody a high magnification triode amplifier in their construction, to step up the A.V.C. voltage to a level suitable for the successful operation of the cathode ray tube.

Such indicators are fascinating things to watch for they can be used for 'silent tuning,' i.e. for tuning the receiver in complete silence with the audio gain control at zero and for comparing the signal strengths of stations by noting the ratios of the areas of fluorescence given by each. They also portray quite clearly how signal strength varies during fading; one can compare the slow gradual fades experienced on the medium waveband with the quick or fluttery effects seen in shortwave propagation.

A.F.C. Another—and perhaps better—way of avoiding small tuning errors is to design the receiver to counteract them automatically. Receivers fitted with such a device, known as *Automatic Frequency Correction* (A.F.C.) make ideal domestic receivers, for even if one tunes perfectly a certain amount of 'creep' inevitably occurs after a few hours. The receiver, a standard superhet, incorporates a 'discriminator' in the detector stage which develops a voltage proportional to the amount of mistuning of the receiver. This voltage is made to apply a small correction to the oscillator frequency so as to neutralize the mistuning effect. Errors greater than 5 kc/s cannot be corrected however.

F.M. Receivers. The same type of discriminator is used in F.M. (frequency modulated) receivers to convert frequency changes into voltage changes which then can feed the A.F. amplifier. The receivers are usually superhets operating on carrier frequencies of 40–50 mc/s, and to avoid noise due to static, interference, etc., which mars A.M. receiver performance, the F.M. receiver is fitted with a 'limiter' which irons out any voltage fluctuations which the receiver has picked up. It is claimed in the U.S.A., where F.M. transmission has now being going on for some time, that the silence of these receivers is outstanding, and that their fidelity of reproduction is a considerable advance over that of the best in A.M. technique. Unfortunately it will be some time after the war before we can assess these claims properly.

LESSON 12

An Outline of Television

FEW subjects have made such an appeal to the imagination of the general public as television, that miracle whereby a scene and the movement occurring in it can be transmitted and reproduced at a distance by means of a radio link. Though the B.B.C.'s high definition service from Alexandra Palace was temporarily closed down during the war, it was clearly stated that a television service would be resumed after the cessation of hostilities.

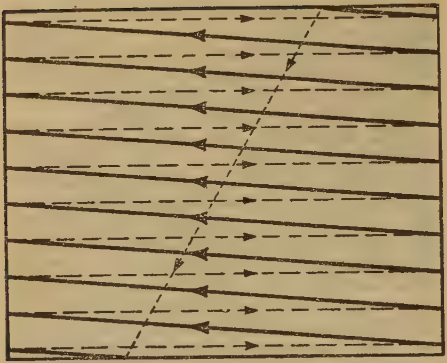
It is impossible in a single short Lesson such as this to do full justice to a very complex subject, but it is hoped to make clear the main principles underlying television transmission and reception.

Cathode Ray Tubes. In discussing valves in Lesson 5 it was pointed out that some of the electrons emitted by the cathode arrived at the anode even when this had no positive charge, which shows that in valve technique the electrons are not 'pulled' out of the cathode by the attraction of the positive anode potential. Indeed this 'pulling' process does not occur until the anode is several thousand volts positive. In a cathode ray tube in which the anode has several thousand volts on it, the emitted electrons acquire a very high velocity and can be focused into a beam, or cathode ray, by suitable electrodes. The beam can be deflected by a magnet or a voltage applied to a controlling electrode. If this beam strikes a specially prepared screen mounted at the end of the tube a spot of fluorescence occurs.

It is on the screen of such a cathode ray tube that the reproduced image of a television receiver is built up: such tubes are also used in transmitters.

Persistence of Vision. The reason why movement in cinema films seems natural and lifelike even though it is composed of a sequence of 'still' photographs is that the impression made on the human eye by a scene remains for a fraction of a second after the scene has been removed. Films are successful by virtue of this 'persistence of vision': the same could be said with equal truth of television. In a television receiver pictures are flashed on the screen at the rate of 50 per second, which is just too rapid for the eye to follow.

Careful scrutiny of a newspaper photograph will show that it is composed of



TELEVISION SCANNING. *Fig. 32. Frame of 10-line scanning system. Dotted lines are ' inactive ' or return strokes of electron beam.*

numerous dots, neatly arranged in rows, each with its particular degree of light or shade. In the same way the scene before the *iconoscope*, the cathode ray tube which is the equivalent of a camera in television technique, is divided into numerous ' elements ' and the picture on the receiving cathode ray tube is similarly built up of small elements, each formed by the electron beam striking the fluorescent screen at particular points.

Television Transmission. We are now in a position to consider briefly the whole process of television transmission and reception. An image of the scene to be transmitted is formed by a system of lenses inside the iconoscope, or television camera, on a specially prepared electrode consisting of thousands of individually insulated caesium cells. Now it is one of the properties of the element caesium that, when suitably treated and mounted, it can develop a voltage proportional at any instant to the amount of light falling upon it at that instant. The image is then swept, or ' scanned,' by the electron beam, which is so controlled that it moves in a series of straight lines.

In the pre-war B.B.C. system there were 405 lines but the system used later in the U.S.A. has 525. The beam travels along each line at a uniform speed, discharging each caesium cell as it touches it, and makes a rapid return stroke to the beginning of the next line. Having completed the full complement of lines, known as a *frame* in 1/50th of a second, the scanning agent then repeats the cycle. An approximate representation of a scanning cycle is given in Fig. 32, which for the sake of simplicity represents only a 10-line frame, the rapid return strokes being shown by the dotted lines. The succession of voltages developed by the sequential discharging of the caesium cells is a faithful copy of the degree of light and shade, i.e. intensity, of the various elements composing the scene. This voltage forms the vision signal, and it is this signal which, after suitable amplification, is used to modulate the carrier wave at the transmitter. Amplitude modulation is generally used in television transmission.

The deflection of the electron beam in the iconoscope is achieved by two oscillators, known as *time bases*, one of which works at line frequency (about 10,000 c/s) and deflects the beam horizontally, and the other which deflects vertically and operates at frame frequency (equal to 50 c/s). In order to provide the constant speed traversal together with rapid fly-back, which is required for both lines and frames, the output wave-form of these time bases should not be a sine curve but should have a ' saw-tooth ' shape, as shown in Fig. 33. Resistance-capacity oscillators of special type are generally used, their push-pull outputs being connected to opposite pairs of deflecting plates in the neck of the iconoscope.

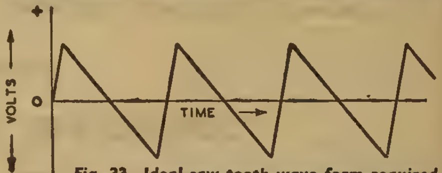
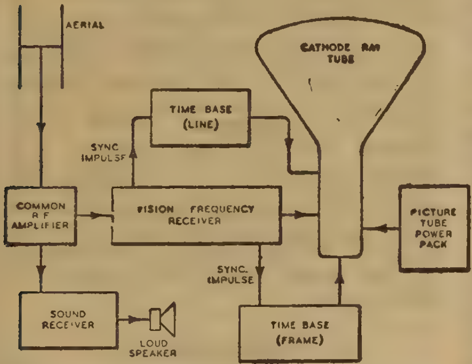


Fig. 33. Ideal saw-tooth wave-form required for deflecting electron beam in television transmitting and receiving tubes.

The modulation depth of the transmission is arranged to vary from 100 per cent (which represents maximum voltage output from the caesium cells and hence full brilliance, i.e. white light) to 30 per cent for zero output from the cells (which represents no light, i.e. complete blackness). The black level has been arbitrarily fixed at 30 per cent so that signals of less than 30 per cent modulation can be used for synchronizing purposes. These will not affect the receiving tube since they represent ' blacker than black.' Impulses of less than 30 per cent modulation are sent out at the end of each line and frame to enable exact synchronization between transmitting and receiving electron beams to be obtained. This will be explained more fully later.

Band-width of Television Transmitter. It follows from Lesson 4, if audio-frequencies up to 10,000 c/s are transmitted, a frequency band of 20 kc/s is required in the ether spectrum. The higher the quality of reproduction required the greater does this bandwidth become. Now a high-definition television service requires an even wider bandwidth than this. In fact, the output of the iconoscope, the vision signal, contains frequencies up to 2 mc/s, so that a channel 4 mc/s wide is required in the ether spectrum. This clearly cannot be obtained in, say, the medium waveband which is only 1 mc. wide. In fact it can only be realized on the ultra-short waveband and the B.B.C. used 45 mc/s (6·67 metres) in its pre-war service, the accompanying sound transmission (which requires an entirely separate transmitter and usually a separate receiver as well) being broadcast on 41·5 mc/s. Such carrier frequencies as these have a range limited generally to about 50 miles, though successful reception of Alexandra Palace was recorded at distances up to 100 miles. In the U.S.A. the sound accompaniment is usually provided by a frequency-modulated transmitter.



TELEVISION RECEIVER. Fig. 34. Block schematic diagram of a complete sound and vision receiver with cathode ray tube, two time bases and power supply.

Television Reception. At the receiving end, a receiver is required, which operates, not a loud-speaker, but the controlling electrode of a cathode ray tube, in such a way that the intensity of illumination at the point where the electron beam meets the screen of the picture tube is directly proportional to the amplitude of the vision signal. In addition to this some means is wanted of deflecting the cathode ray stream so that the spot of illumination on the screen moves in the same way as the exploring spot in the transmitting iconoscope. It must not only move along the 405 lines at the same speed as the beam at the transmitter, but must at every instant of time be at the same point in the same line as the beam at the transmitter. This desirable result is achieved by the use of two time bases, similar to those used at the transmitter, with their outputs applied to the deflecting plates as before. The frequencies of these generators of 'saw-tooth' wave-forms is deliberately made slightly less than the theoretical requirement and arrangements are made for the synchronizing time impulses (of less than 30 per cent modulation) to 'trip' the oscillators slightly before they have reached the end of their cycle. Exact synchronization is secured between the movements of the transmitting and receiving electron beams.

A block schematic diagram of a complete television receiver is given in Fig. 34. It will be noted that this consists of two receivers, a cathode ray tube, two time bases and associated power supply systems. A specially designed power pack delivers low tension and a few thousand volts of high tension for the operation of the receiving picture tube. This, of course, is concerned purely with the actual production of the electron beam. Deflection of it, horizontally and vertically, is achieved by the two time bases, which are 'triggered,' as already explained, by the impulses of less than 30 per cent modulation, which are derived from the detector stage of the vision receiver proper as indicated in the diagram. Modulation of the electron beam is by the voltage output of the vision receiver proper.

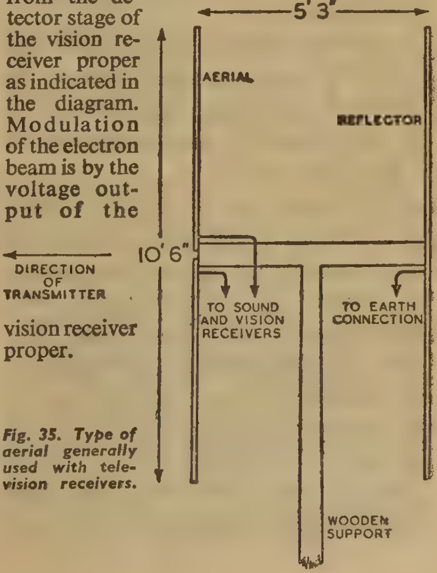


Fig. 35. Type of aerial generally used with television receivers.

As the sound and vision transmissions are usually carried out on neighbouring frequencies it is possible to use a common R.F. stage for both sound and vision receivers, as shown in Fig. 34. This idea has the advantage that only one aerial is required for the two receivers. The aerial system used consists generally of a dipole half a wavelength long (10 ft. 6 ins. for 6·67 metres or 45 mc/s), backed by an earthed reflector as shown in Fig. 35. The arrangement should be directionally placed so that the dipole is between the reflector and the transmitter. The aerial should preferably be placed at a high point, such as on a chimney.

The receivers themselves may be built either on the straight or superhet principle and as each is only used for reception of one particular carrier frequency, tuning can be preset during manufacture of the receiver at the factory. A typical straight vision receiver will have five stages of R.F. amplification using special high-slope pentodes, a diode detector, and a pentode output stage. Despite the large number of R.F. valves the overall amplification is not enormous for the stage gain of each pentode is quite low (about 10) due to the very high working frequency and the wide band-width required. The output stage is required to give a very modest power output, for modern cathode ray tubes can be fully modulated with only 9 volts input applied to the control grid.

A superhet type of vision receiver will generally use an I.F. of between 5 and 10 mc/s; it cannot be lower owing to the difficulty of attaining the 2 mc/s band-width necessary. Consequently there are roughly the same number of valves in this type as in the straight receiver.

The sound receiver can be quite a normal type of superhet with an I.F. of 16 mc/s, but, of course, the operating frequencies of the R.F. stage (which it shares with the vision receiver) and the oscillator section are tuned to 41·5 mc/s and 59·5 mc/s respectively. The sound transmitters are usually noted for their exceptionally good fidelity, this being superior to the performance of medium-wave transmitters, the reason for this being, of course, that there are no restrictions on the band-width which can be occupied by a transmitter which works on 41·5 mc/s.

For the sake of economy both sound and vision receivers may be operated from the same power pack. An additional pack supplying about 1,000 volts will be necessary, however, to energize the two time-bases.

Despite the complexity of the apparatus in a television receiver it normally has very few controls. A typical receiver has usually only five. The focusing control, as its name suggests, regulates the area of the spot of fluorescence where the electron beam meets the screen. This control usually takes the form of a potentiometer connected in the H.T. supply to one of the several anodes possessed by the average cathode ray tube. The grid bias of the tube can be made adjustable in a similar way by means of a potentiometer and is used to vary the mean brightness of the screen, this being known as the *brilliance* control. The difference in illumination between the bright and the dark parts of the reproduced image, known as the *contrast*, is adjusted by a third knob, known appropriately enough as the 'contrast control.' The remaining two controls are concerned with horizontal and vertical *framing* and serve to bring the frequency of the horizontal and vertical time bases frequencies sufficiently near the correct values for the synchronizing time impulses to 'take charge' and 'lock' them at the correct values.

BOOK LIST

Elementary. 'A First Course in Wireless,' 'Decibel' (Pitman); 'The Outline of Wireless,' Ralph Stranger (Newnes); 'Foundations of Wireless,' A. L. M. Sowerby (Iliffe); 'Problems in Radio Engineering,' E. T. A. Rapson (Pitman); 'The Amateur Radio Handbook,' ed. J. Clarricoats (Radio Society of Great Britain); 'Radio Upkeep and Repairs for Amateurs,' A. T. Witts (Pitman).

General. 'Modern Radio-Communication,' J. H. Reyner (Pitman); 'The Elements of Radio-Communication,' O. F. Brown and E. L. Gardiner (Oxford University Press); 'The Physical Principles of Wireless,' J. A. Radcliffe (Methuen); 'Radio Receivers and Transmitters,' S. W. Amos & F. W. Kellaway (Chapman & Hall); 'Handbook of Wireless Telegraphy,' (Admiralty: H.M. Stationery Office).

Television. 'Television Receiving Equipment,' W. T. Cocking (Iliffe); 'Television Today and Tomorrow,' S. A. Moseley and H. J. Barton Chapple (Pitman); 'Television Reception Technique,' P. D. Tyers (Pitman).

Valves and Cathode Ray Tubes. 'Thermionic Emission,' T. J. Jones (Methuen); 'The Cathode Ray Oscilloscope,' W. E. Miller (Iliffe); 'Applications of the Cathode Ray Oscillograph in Radio Research,' R. A. Watson Watt, J. F. Herd and L. H. Bainbridge-Bell (H.M. Stationery Office).

LAW

An understanding of the law and constitution of the country, and of the foundations underlying them, is an essential part of good citizenship. The following Course on Law consists of two parts: the first deals with British law as it affects the ordinary citizen, the second with those special laws and customs which make up Britain's unwritten and elastic constitution.

The parts played by Parliament, by the Courts of Equity, by the judges, and by the legislature in creating the present body of British law are explained, together with many other important, interesting, and curious points, as well as the citizen's rights, duties, and privileges in relation both to the law and to the constitution. A parallel study of the Course on British History *in Volume VI will add to the interest of the present Course.*

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LESSON ONE

Fundamentals of Jurisprudence

What is the average citizen's attitude towards the law? In time of war, when he finds himself constantly in danger of breaking some of its innumerable and complicated provisions, however great his care, he accepts its never-ending and often blundering interference with the best grace he can command. He knows, too, that he has to expect such interference to continue for some considerable time. When more normal conditions return, however, the citizen adopts again the attitude which can best be described by saying that for nine-tenths of his existence he gives the law no thought.

Indeed, this very lack of interest is the main reason why it is so very difficult to bring about the many reforms that are urgently needed today, in both the machinery and the substance of the law. When the average citizen is compelled to direct his attention to the law, it is usually because he has infringed some minor rule which to him seems to have been invented solely to annoy him; or it may be that he receives his first impression when engaged in some civil action in the courts, and then he will probably find the proceedings excessively dilatory and expensive, and the methods of inquiry into the matter before the court much more complicated and less effective than those he is accustomed to apply himself in making decisions in his ordinary business affairs.

Law Means Order and Stability. This attitude is unfair to the law, because it blinds the citizen to the real benefits which the law, in spite of many undoubted defects, does provide for him. A further consideration of the matter would show him that the law is largely responsible for introducing order and stability into his life. Without it he could live but from day to day, and his life would be 'nasty, brutish, and short.' The punishment of crime by the law increases the probability that he can go about his normal business without being violently attacked by someone desirous of taking from him his note case and loose cash; by enforcing contracts, the law enables him in his business to enter into engagements with others to be carried out at some future time and to plan his affairs on the assumption that these engagements will be duly carried out.

Conditions of Freedom. It may be said that the object and function of the law is to maintain an orderly state of society by compelling the individual in close association with other individuals to live in such a way that he pays some regard to the private wills and pleasures of the others, and does not act as if his own interests were everything and theirs nothing. Thus, in one direction the law deprives a man of his full freedom by limiting his powers—e.g. his power to assault and rob his neighbours—but in another direction it increases his freedom, for he will in his turn be free from the untrammelled assault and robbery of his neighbours.

Man has always been an essentially social being, delighting in the companionship of his fellows, and even in the most primitive times has tended to form societies or groups, either because of this social instinct or for protection. This instinct still survives and operates to bring into existence the innumerable clubs and societies which are to be found in every community.

In early times the unit may at first have been very small, merely the family, but even in that unit some form of social order is required; and as the unit becomes larger, in the village and finally the State, the need for some social order is recognized as a necessary condition of social intercourse. Social order can be obtained only by the observance by the members of the unit of some rules of conduct towards one another, for otherwise life together would be impossible. The larger the community the more numerous and complex are these rules of conduct, but their object is the same.

Rules of Conduct. If we examine the rules of conduct existing in any community it will be found that the members of the community obey some rules for one reason and others for other reasons. In most communities a man is expected to greet a friend whom he meets in the street and not to ignore him; he is expected not to tell lies, and if he accepts an invitation to dinner he is expected to keep the appointment. In the first and last of these instances the rule of conduct is founded on convention, and in the second instance on morality. If a man fails to observe any of these rules he will suffer in some way or other. His friends will cease to speak to him in the street, or will not believe his word, or will not again ask him to dinner. In other words, he will find that 'public opinion' is against him, and so it is by public opinion that such rules are enforced. Again, every club or society, in the narrower sense of the word, has certain rules the breach of which is punished by expulsion from that club or society.

But there are some rules of conduct the observance of which is not enforced by public opinion, or not by that only. If a man assaults his neighbour or drives his motor-car in a dangerous manner, he will find he has offended something more important than public opinion, namely the State, which will attach certain penalties to his breach of the rule, over and above any that may be imposed by public opinion, and may fine him or deprive him of his freedom by sending him to prison. It is this attribute of State enforcement which distinguishes rules of conduct that are 'laws' from other rules of conduct, and so a law may be defined as 'a rule of conduct enforced by the State.'

Law and Public Opinion. It should be noted that it does not follow from this that laws are not also enforced by public opinion. Every law should have the support of public opinion, and in very many, if not the majority of cases, the fear of public opinion will be more effective in enforcing the laws than the fear of the punishment imposed by the State. Thus the average man refrains from cheating at cards, not because he is afraid of being punished by the law, but because to cheat would either offend morally or would lead to his friends' refusing to play with him again. Conversely, when public opinion does not require the observance of a certain rule of conduct which is law, the average citizen will not hesitate to break the rule.

The definition of a law as a 'rule of conduct enforced by the State' requires some elaboration. First, it should be noted that the definition relates only to rules of *conduct*. The State will not interfere with the thoughts or desires of its members until such thoughts or desires are expressed in conduct, for the very good reason that until that time they can in no way affect other members of the community.

It should be pointed out that the law has not always confined itself to conduct, even in this country. It has sought out a man's thoughts and punished them as crimes. As late as the days of Queen Elizabeth anyone might be seized and brought before a tribunal which then proceeded by a series of questions to find out his views on such matters as the Pope's right to excommunicate and depose the Queen. Torture might be used to compel him to answer, and mere refusal to answer could be regarded as a confession of guilt. Even in the 16th century, however, the procedure was regarded with disfavour, the Queen herself declaring that she would make no window to look into a man's soul. These methods will at once recall those of the Spanish Inquisition, and those revived along with other medieval practices by some of the dictatorships in Europe in the twentieth century.

The State does not enforce all its laws in the same way. In the case of those the breach of which is considered to be so serious in its effects as to endanger all the members of the community—i.e. the criminal laws—the State will itself intervene to have the offender punished.

In other cases—breaches of conduct which are merely civil wrongs, for example—the State will not interfere unless the member of the community who has been injured invokes its aid by suing the offender in the courts. In still other cases the State will in no circumstances inflict any punishment for the breach of the law, but will merely refuse its aid to any member who does not comply with the legal requirements. Here it directs but does not command. Thus, in most countries, certain transactions must be carried out in a formal way; if any person attempts to sell land or to make his will without observing the required formalities, the State will merely refuse to recognize the validity of the sale of land or of the will, and will not lend its aid to the enforcement of the informal transaction. To this branch of the law belong the rules governing the proceedings in the courts.

LESSON TWO

The Laws of Man and the Law of Nature

To talk of the origin of law in a society is apt to be misleading, for it might be taken to imply that a society can exist without any law and that law is developed only after the society has come into existence. From what has already been said of the nature of law, it will be appreciated that this view is incorrect; it is impossible for individuals to live together in a society without the rules of conduct which we call law. Law was not imposed artificially upon a primitive society after its formation, but was a natural growth and a condition of the formation itself. The existence of a society presupposes the existence of law.

Early Codes of Law. It is necessary to stress this because the study of the history and tradition of early communities might at first sight appear to lead to a contrary conclusion, since at a very early stage we find a record of the establishment of a code of law by some lawgiver. Some of the codes which have been preserved are of very great antiquity; the earliest known is the code of Hammurabi, which is earlier than 2000 B.C., and other well-known examples are the Ten Commandments of Moses and the Twelve Tables of the Romans. These codes cover a considerable part of the life of the societies for which they were framed, dealing with many matters which we should today consider religious rather than legal, as well as with legal matters proper. There is no doubt that in early times these codes were regarded as laying down and creating new law and as the origin of the law of the State, and this is indicated by the word 'lawgiver' applied to their compilers. This view can, however, no longer be accepted, for it is now clear that these codes were collections and publications of laws previously existing in an unwritten and indefinite form.

In addition to being supported by historical researches, this view is also more in accordance with the probabilities. The early community must have had to solve many problems arising between its members in which their rights had to be defined. At a very early stage in the organization the power of deciding who was right and who was wrong in these disputes must have been placed in the hands of a person in authority, a person not only with ability to decide the question but also with power to compel the parties to abide by his decision. This person was usually the priest of the tribe who acted as both judge and priest, thus illustrating the close association in early times between religion and law.

Declaring the Law. Imagine such a judge deciding a dispute. There may be some tribal custom covering the point, or it may have been the practice of previous judges in previous decisions to decide a similar question in a certain way. If there is some such custom or decision the judge will probably follow it. But if there is no custom and the matter has never been decided before, the judge will decide it according to his own ideas of right and wrong. He will probably not admit that he is doing so, for that would amount to an admission that he is making law, but he will state that he is 'declaring' what has always been the law of the people. This attitude, as will be seen later, is that taken at the present day by the law of England with regard to judicial decisions.

When the judge has given his decision in the case imagined, this decision will be a guide to himself and later judges in later similar cases, handed on probably by oral tradition and teaching, and gradually a system of law will come into existence. This law will at first be purely traditional and a closely-guarded secret reposed in a privileged class of judges. It is only at a later date that some person will embody these scattered rules in a written code, and this will usually happen as the result of some democratic revolt against the privileged class, when the democracy realizes the power that is given to the privileged class by having a monopoly of the knowledge of the law. Thus in early communities law is not made beforehand to meet cases and circumstances which may possibly arise, but is only declared as each case comes before the judge, although the judge purports not to be making new law but to be declaring what has always been the law. An early code does not contain new laws but is the publication of existing laws. It is the 'making public' that is new, not the laws themselves.

It has been said above that the judge, in the absence of any custom or previous decision, will decide the case according to his own inherent ideas of right and wrong. It is a strange fact that men in all communities when required to decide as to right and wrong have arrived at the same decision on very many points. This explains why the ultimate principles of law are everywhere the same. So striking has this similarity been that so soon as a science of jurisprudence was evolved, that is, so soon as jurists began to examine the laws of their own country and to compare them with those of other countries, the similarity was at once recognized. Jurists have expressed this idea by saying that this common idea of right and wrong was the law of Nature and that the law of Nature was the source of all law—an unwritten law ingrained in the heart of Man, which all human beings were everywhere bound to recognize, and to endeavour to obey.

The Law of Nature. This theory of the law of Nature has been greatly developed by some jurisprudents, even to the extent of declaring that all laws must conform to the test of reason governing the law of Nature, and that men have certain rights under the law of Nature of which they have in certain cases been deprived by the law of the State. This view has had a very great influence on philosophy and politics, and gave rise to the ideas contained in such expressions as the 'natural rights of Man' and in Rousseau's declaration, on the first page of his 'Social Contract,' that 'Man is born free, but is everywhere in chains'—which in due course became the maxim of the French Revolution.

In the law considered here, however, that is, the law enforced by the State, there is no room for this view. If a law is in conflict with what someone may declare to be a part of the law of Nature, the law will nevertheless be enforceable; it may be true to say that a law which is unreasonable should be altered, but until it is altered it remains the law of the State. Further, where judges, in the absence of custom or previous decision, have decided a case upon their own ideas of right and wrong, it may be said that the source of their decision is the law of Nature, but the proposition declared as law by them is law *because* it has been so declared and not because it is part of the law of Nature. If a judge gave a decision which was unreasonable, and therefore, presumably, contrary to the law of Nature, it would nevertheless be law, unless and until his decision was altered by a higher court.

It is by no means unknown for a judge in giving a decision to state that he recognizes that his decision will cause hardship, but that he regrets he is compelled to decide in this way because of previous cases which he must follow.

LESSON THREE

How Laws Change

We have seen that the publication of a written code occurred at a comparatively early date in the history of most communities. While the advantage of publicity was no doubt great, the writing down of the law was also attended by disadvantages of equal importance. The chief of these were a complete loss of elasticity in the law and the growth of formalism.

Even the best system, or code, of laws can provide only for the needs of the community at the time when it is formulated. As a society progresses, so its needs change. Before the law has been declared in a code, those who administered the law were free to a large extent to do what they felt was justice in any case that came before them, and as new circumstances arose they could be dealt with on their merits by a spontaneous development of the law. The code, however, while, on the one hand, it specifically recognized certain rights, on the other, by necessary implication, denied the existence of any rights not so specifically recognized, and put an end to the possibility of spontaneous development. Only those rights could be enforced which were conferred by the code; other rights, though similar in kind, were unknown to the law.

Even, however, in cases where the code did establish a certain right, anyone who wished to enforce that right must do so in the manner prescribed, presenting his case in the approved form and carefully following a complicated procedure, a single departure from which would be fatal to his claim. Today the courts in Great Britain will never allow a technical error in procedure to prevent justice being done between the parties, but such elasticity is of recent growth. In the early law a man who alleged that his neighbour had struck him with his left hand when, in fact, the blow had been struck with his right hand, would have had his case dismissed without its merits ever being considered by the court.

In many communities these two defects have never been effectively overcome, and the society is to this day burdened with an archaic code and rules of law belonging to a stage in its history long since past. Such communities have paid the penalty; they have attained a certain stage of civilization, but have progressed no further. An excellent illustration of this is provided by the Hindus. The complicated system of their laws, inextricably mixed with religion and full of irrational and ceremonious extensions of what were in their origin sound rules of health or morality, has presented an insuperable obstacle to progress.

Principal Agents of Change. It is only the communities that have been able to adjust their laws to fresh circumstances and new demands that have progressed. In such societies there have been three great instruments of change—legal fictions, equity, and legislation—and almost without exception they have made their appearance in that order of time. The method of change most familiar to us today—i.e. legislation—is almost unknown in the early state. Legislation involves a deliberate and conscious alteration of the law, and, by implication, an admission that the previous law was imperfect; in the early state alterations are brought about unconsciously and almost surreptitiously.

The popular modern view is so very definite that the more the law is changed the better it will become, that it is not perhaps easy to appreciate that, until a very late period in the history of a State, the law was regarded as perfect, sacrosanct, and incapable of improvement. This view is expressed by Sir William Blackstone as late as the second half of the 18th century. It should further be borne in mind that to many codes a divine or quasi-divine origin is attributed, and their alteration by the hands of Man is therefore unthinkable. Thus it is that the first changes came in disguise; and this will help to explain the devices and tricks to which lawyers of old resorted to achieve a result which in our day might be obtained by an Act of Parliament of ten lines.

Legal Fictions. The great weapon of the lawyer which enabled him to disguise the fact that he was changing the law was the legal fiction. This satisfied the desire for improvement without offending the superstitious dislike of change. These fictions are found in the legal systems of all countries which have developed a progressive civilization, and usually involved the allegation by one party of a fact, which, although untrue, the other party was not allowed to deny. Two illustrations from English law may be given.

Until the 19th century the Court of Exchequer was in theory reserved for cases which concerned the royal revenues. That court was, however, enabled to hear other cases by the plaintiff alleging that he was the king's debtor and was unable to pay his debt because the defendant would not pay him (the plaintiff) what he owed. This was or might be untrue, but the defendant was not allowed to deny it, and the Court of Exchequer could try the case.

Doe and Roe. Another and more famous fiction is connected with the names of John Doe and Richard Roe. Anyone who cares to look at the English law reports of a century and more ago will find many cases entitled 'John Doe on the demise of . . . . . against Richard Roe,' and may be somewhat surprised at the litigious disposition of the two. This surprise will perhaps be greater when it is realized that neither John Doe nor Richard Roe ever existed in the flesh, but were merely the creations of some ingenious lawyer to enable the courts to recognize and protect rights in a manner in which, strictly, they were not entitled to act. The old law provided no easy or simple method by which the title of two claimants to the *freehold* of a piece of land could be decided. The law did, however, provide a comparatively simple method, known as the writ of ejectment, enabling the holder of a *lease* of land to establish his title to the lease if he were ejected. This writ of ejectment was made available for the freeholder by the following ingenious device.

The claimant to the freehold in the land went on to it with two friends. To one of them he granted then and there a lease of the land, whereupon the other, called the casual ejector, immediately turned the lessee off the premises. The lessee then brought the writ of ejectment against the casual ejector, and the person in possession of the land, i.e. the other claimant, was allowed to defend in the place of the casual ejector. The question immediately in issue was whether the lessee had a good lease, and as that depended on whether the first claimant had power to grant the lease or not, the decision of this point also decided the title to the freehold, because the claimant could only have power if he owned the freehold.

Soon the preliminary formalities were dispensed with, and the declaration which commenced the action stated that A (the claimant) had leased the land to John Doe, but that Richard Roe (the casual ejector) had turned him out of possession. The real defendant, the person in possession, was allowed to defend in place of the imaginary Richard Roe, but only on condition that he admitted the (entirely fictitious) granting of the lease to the (non-existent) lessee, Doe. The ensuing action was thus entitled 'Doe on the demise (i.e. lease) of A against Roe.' Thus an entirely new method of enforcing the right to the freehold of land had been created without any apparent change in the law. This legal fiction persisted until 1852, when it was abolished by the Common Law Procedure Act.

LESSON FOUR

The Origin and Meaning of Equity

ARISTOTLE has pointed out that legal rules are necessarily general, whereas the circumstances of individual cases are particular, and that it is impossible to provide in advance for all the situations which may arise. Thus at certain points it is inevitable that circumstances must arise for which the law has made no provision. It is here that equity, the second great source of the law, appears. Where the established law is working an injustice, either because of the narrowness of its rules, or because the particular case which has arisen was never contemplated when the rules were framed, there is some authority in the State which can intervene and by the aid of equity prevent the injustice.

Equity. The meaning of equity is most nearly defined as reasonableness or fairness. It would be a mistake to imagine that equity was willing to interfere in every case in which the law worked something less than justice, or that the equity of present-day English law plays any such part. In all equitable systems it is only in the very earliest times that those administering equity are bound by no rules except their own ideas of right and wrong; in such times the old taunt against the English equity—namely, that it varied with the length of the chancellor's toe, i.e. it was pure caprice—was no doubt true. But it is a strange feature of all equitable systems that in a short time they lose their original elasticity and develop into as rigid a code of rules as the old law, the harsh application of whose rules they were designed to moderate. It is more important that the law should be certain than that it should be fair in all cases, however unusual.

Equity should be regarded as a process for effecting changes in the law belonging to a middle period in legal history, later than the legal fiction, but earlier than legislation. This historical sequence is what one would expect if one remembers the strong dislike to any change in the law found in the early society. With the legal fiction the change is hidden and disguised; with equity the change is more openly avowed and the old law, although it still remains, is deprived of its effect. Finally, with legislation the old law is openly declared to be wrong, and new law substituted.

The Roman and English legal systems each developed a different but very vigorous type of equity. In Rome the growth of equity was due largely to the growth of commerce and the consequent intercourse between Romans and non-Romans. For example, the old Roman contract—like its equivalent in English law, the covenant under seal—was formal and cumbrous and unsuited to the needs of a trading community. Moreover, none but Roman citizens could enter into it owing to its religious character. Thus intercourse with the outside world made necessary some form of contract of a simpler kind into which non-Romans could enter.

The Roman official whose duty it was to regulate the relationship between Romans and non-Romans was the praetor. He had no authority to make law, but he had to decide any disputes which came before him as best he could. By means of these decisions he built up a system of law outside the formal law applicable to Roman citizens, but suited to the needs of a trading community. At first this law applied only where a non-Roman was concerned, but the advantages of the new informal rules over the old formal rules were so obvious that soon we find the new law being applied to Roman citizens also. The old law still remained unrepealed, but its provisions fell into disuse, and the new rules, introduced not by legislation but by equity, took its place. A similar departure from the strict formal rules of contract by equitable principles is visible in Scots law. There no contract was valid unless it was entered into with certain complicated formalities. As trade developed it became impossible to comply with these rules, and the courts accordingly declared that all contracts of a mercantile character were privileged, i.e. exempt from the strict formal rules.

Courts of Equity. It is in English law, however, that equity is seen in its most vigorous state, for here it not only created fresh legal principles in aid of the common law, but also established separate courts, distinct from the common law courts, in which these principles were administered. This division had the peculiar result that a suitor who took his case to the common law courts would have judgement given against him if he wished to rely on equitable principles, and might thereafter have to apply to the equitable courts to have his right established. It is true that the common law courts in many cases added to the law by introducing new principles to adapt it to changed circumstances and that in so doing they were administering equity in its general sense. But in English law the word has acquired a special meaning, as those innovations and adaptations which were introduced and administered in the courts of equity only.

Common Law. This is law which, at first consisting of customs and usages, came to be principles enunciated by judges who tried cases which came before them. It is therefore based upon precedent and since it derives from cases decided by judges for many years past, it is technically known as case law. From the reported judgements the lawyer deduces, in any particular legal problem, the principle he needs to decide that problem. The term common law is also used to distinguish the law primarily administered by the King's Bench Division (*see* p. 458) from that primarily administered by the Chancery Division which is called equity.

The Chancellor. The king was recognized as the fount of all justice, and when he ceased to hear cases himself and delegated his duties to his judges, he was still regarded as retaining a jurisdiction to do justice in cases where these judges in applying the law had failed or were unable to do so. This residual jurisdiction came in time to be exercised by the Chancellor, who in early times was invariably a churchman. This fact is of the utmost importance. First, the Chancellors had behind them a training in the canon law (the law of the Church), and in Roman law, and thus by their decisions introduced into English law many principles of these legal systems; secondly, the Chancellors, as churchmen, tended to consider whether the conduct of the parties before them had been according to good faith or to conscience, and they would compel the parties to act as conscience dictated. The Chancery Court was named after them.

Trusts. One of the most important principles which we owe to the equitable rules introduced by the Chancellors is the doctrine of trusts. We today accept without question the idea of a man holding property apparently as owner, but in reality as trustee for another and so bound to use that property for the benefit of that other. To the common law, however, the doctrine was unknown, and if the trustee refused to obey the terms of the trust and used the property for himself the common law would not interfere. But such conduct on the part of the trustee was clearly against conscience, and the court of equity would compel him to observe the terms of the trust. It did not contradict the common law; it merely added to it. The common law said the trustee owned the property; equity did not deny this, but said that, although he might own the property, he must nevertheless use it in a certain way only—i.e. according to the terms of the trust. The trustee was said to have the *legal* title to the property and the beneficiary to have the *equitable* title.

Legislation. Legislation is always the last method by which changes are made in the law. In Great Britain the last hundred years or so have been a period of very great legislative activity. The great landmarks of that period are probably the changes in the criminal law made in the first half of the 19th century, including the abolition of the death penalty for such offences as theft; the changes in the courts made by the Judicature Acts, 1873 and 1875; and the revolution—it is not too strong a word—made in the law relating to land in 1925. In the last hundred years there is probably no branch of the law which has not been changed by act of Parliament; and today, in place of the old attitude that the law was perfect, upheld by very eminent lawyers as late as the end of the 18th century, we have very nearly reached the attitude that change is desirable for change's own sake. In the early state antiquity was a merit of itself; today it is a fault.

LESSON FIVE

State Sovereignty and Its Meaning

In whom does the sovereign power in a State reside? There is no question which has received more of the attention of political philosophers, or to which more ingenuity has been devoted. Further, there is probably no subject on which more divergent views have been held, or about which there has been more confused thinking and writing.

This confusion is due to many causes. First, the idea of sovereignty involves the consideration of questions which are ethical and political as well as legal. One desires to know, not merely who is sovereign, but also to know under what authority he is sovereign and whether that authority is one that is ethically justifiable. Writers have, therefore, approached the subject from ethical and political as well as legal standpoints. They have not been concerned merely to state and interpret facts as they have found them, but have been impelled to state the facts and, if necessary, to manipulate them so as to justify some particular form of government. They have written as politicians and advocates rather than as disinterested commentators.

Hobbes' Conception of the State. Hobbes, for instance, at the time of the Civil War made his 'Leviathan' not a treatise but a political pamphlet. He was hostile both to the Anglican theory of the divine right of kings and to the Presbyterian theory that sovereignty was based upon a covenant made by the people with God. He, nevertheless, was anxious to propound some theory of sovereignty which supported autocracy and discouraged revolution. With these motives in his mind he invented the theory that sovereignty was reposed in the king by virtue of a covenant, not between the sovereign and his people—for that might be revocable in certain circumstances—but between each member of the community and each other member, under which they agreed to surrender all their rights and powers into the hands of the sovereign. Under this theory the authority of the sovereign could not be revoked, whatever his conduct might be, for he was not a party to the contract. As a legal theory this ignored the facts and was based upon a fiction, but as a political weapon it had the advantage that it afforded a support to autocracy, and without invoking divine aid discouraged insurrection against the sovereign.

The second cause of confusion is that sovereignty is an ill-defined word, used in many different senses. To a layman the word usually means supremacy, and in a State that person is sovereign who can compel others to act as he wishes, and can act himself without regard to their wishes. This is sovereignty de facto. To the lawyer the word, however, has another aspect. He is concerned, not so much with the person who in fact is obeyed, as with the person who, according to the law, should be obeyed. This is the legal sovereign, the sovereign de jure.

The legal sovereign can always be determined by discovering who has the ultimate right to make the laws of the country. It may be that, in fact, some laws are made by a person or body to whom power to make them has been delegated, and in this case it is necessary to inquire further and see by whom the power was delegated and under what authority. When in this process we arrive at some person or body to whom no power has been delegated, but who makes laws or delegates that power to others simply because it is the law that it should be entitled to do so, then that person or body is the legal sovereign.

Tracing the Legal Sovereign. Let us suppose a householder wishes to erect a garage in his garden. He is informed that the roof must be made of asbestos. He asks under what authority this is laid down, and is referred to a by-law of the local council. If he goes further and asks under what authority the local council made such a by-law he will be referred to an act on the statute book which delegated this power to the council. This act he will discover was made by Parliament, and if he asks under what authority Parliament made it, he will receive the answer that no person has delegated power to Parliament to make laws, but that it is the law that Parliament can make laws. He will then have found that in Great Britain Parliament is the legal sovereign. If a similar process were applied to a State governed by an absolute monarch, e.g. to France under Louis XIV, the result would again be the discovery of the sovereign power, in this case the king himself.

The application of this process to a number of different States will lead to an interesting discovery, namely, that in some States there is more than one legal sovereign, the legal sovereign for some purposes being one body and for other purposes another body. In the United States of America, Congress has power to make laws on some subjects binding on all the States, but on many subjects, e.g. marriage, each State makes its own laws through its own State legislature. Further, there are some laws which cannot be made or altered by either Congress or the State legislatures separately, but under the constitution must be made or altered by the combined actions of specified majorities in Congress and the State legislatures. Thus for some purposes Congress is the legal sovereign, for others the State legislature, and for still others a combination of Congress and State legislatures.

Limitations of Sovereignty. There is, however, nothing contrary to reason in having this multiplicity of legal sovereigns, for the will of each is legally supreme in the region in which it is sovereign. Moreover, not only may the legal sovereignty be divided but it may also be limited. Thus in the United States the constitution forbids any legislature to interfere with the primordial rights of the citizen, e.g. the right of free speech and public meeting. In England the sovereignty of Parliament is unlimited, for it has been said that Parliament can do anything but make a man into a woman or a woman into a man.

Sovereignty in the popular sense or de facto means the person or body whose wishes are, in fact, observed in the State. The sovereign de facto may also be, and usually is, the legal sovereign. It should be so, for in a well-regulated State might should be combined with right. But a State may be well governed even though the two are separated. Thus the sovereign de facto may act through and in the name of the sovereign de jure, as happened in England when Cromwell ruled through the Rump of the Long Parliament, and as happened in Italy when Mussolini, as sovereign de facto, existed side by side with and acted through the legal sovereign, a constitutional monarch.

In England today, while the legal sovereign is Parliament—which, it should be remembered, consists not only of the House of Commons, but also of the House of Lords and the king—it is probably true to say that the de facto sovereign is the House of Commons. That the king should today refuse his consent to any bill which has received the approval of the House of Commons and the House of Lords is most improbable; and although the House of Lords might still reject measures which have been passed by the House of Commons, yet since the passing of the Parliament Act of 1911 the House of Commons has the ultimate power to impose its wishes upon the House of Lords, and is thus the de facto sovereign. Indeed, the Parliament Act goes far to give legal sovereignty to the House of Commons and the king.

LESSON SIX

Legal Definition of a Crime

The average layman defines a crime with reference to its consequences as some act for which he may be punished by a criminal court. Any attempt to define a crime with reference to the nature of the act, as distinct from its consequences, is beset with great difficulties. The distinction between crimes and civil wrongs is found in every civilized state, but it is not easy to arrive at an exact definition of a crime which will explain the distinction.

At first sight the most obvious practical distinction is that the State, on behalf of the community at large, takes cognizance of a crime without waiting for the person injured to invoke its aid, whereas, in the case of civil wrongs, it is left to the individual injured to set the law in motion against the person who injured him. For example, if A ‘ holds up ’ B on the street and robs him of his watch, the State will take criminal proceedings against A to bring about his punishment, even though B does not invoke its aid; if, however, B, having borrowed A’s watch, refuses to hand it back when asked to do so, the State will not interfere. A may himself start civil proceedings against B for detaining the watch, and if he does so the State will order B to return the watch, but unless A brings the matter to the courts the State will not interfere. The reason is that it is a crime to rob a man of his watch; but it is not a crime to refuse to hand back something you have borrowed.

Setting the Law in Motion. This distinction is of value, but there are two objections to it. First, it is always open to a private individual to commence criminal proceedings just as he may commence civil proceedings, although it is still true that the State, if he does not act, may act in criminal proceedings but cannot do so in civil proceedings. Secondly, the distinction is not one which relates to the *nature* of criminal and non-criminal acts, and still leaves to be answered the question *why* the State will interfere in certain cases and not in others.

Another distinction that may be suggested is that crimes are wrongful acts which violently offend our moral feelings. This, again, is of value as a rough test, but no more; for a breach of trust, or a breach of contract, which are both mere civil wrongs and not crimes, may be much more offensive morally than many crimes, some of which, e.g. failure to take out a dog licence, can scarcely be said to involve any moral turpitude. Again, we cannot say that every act which injures the community is a crime, for the civil wrongs mentioned above may do great injury to the community.

Punishment and Compensation. The idea of punishment also helps us to another distinction. When a civil wrong has been committed and the law is invoked by the person injured, the law is not concerned to *punish* the wrongdoer, but to *compensate* the injured person. In assessing the damages the court will be concerned, not with the degree of moral guilt involved in the defendant's conduct, but solely with the results of his conduct to the plaintiff. In the case of a crime, however, the object of the court is to inflict on the criminal the punishment deserved by his conduct.

To give an example: If A, a motorist, drives his car at 40 miles per hour down a crowded street and runs into B's car, his acts constitute both the crime of dangerous driving and the civil wrong of causing damage by negligence. Let us assume that for the first of these A is prosecuted by the State and convicted in a criminal court, and for the second sued and found liable in damages in a civil court. In calculating the punishment to be imposed upon him for the criminal offence the court will consider not only the damage done to B's car, but also the speed at which A was driving, the likelihood of injury, the extent of the danger, A's past record. In calculating the damages which A must pay to B only the first of these will be relevant; the court will consider only what it will cost B to have his car repaired.

A civil wrong, further, may always be pardoned or settled out of court by the person injured, but it is of itself a crime to agree either not to institute, or to withdraw, a criminal prosecution on payment of a consideration. So if my dog is stolen I cannot advertise in the paper and say that if it is returned a reward will be given and 'no questions asked.' This again illustrates the principle that a crime concerns, not only the criminal and the injured person, but also the State.

Characteristics of a Crime. We may now conclude that a crime has the following characteristics, and, generally speaking, may be distinguished from other illegal acts by means of these characteristics:

(1) It involves a moral wrong; (2) it injures the community or a large part of it; (3) the State on behalf of the community will interfere to punish the act; (4) the State in punishing the act is concerned not with the loss caused by the crime to any person, but with the quality of the act done by the criminal.

Hitherto we have considered a crime as we find it in the law of civilized states today. If, however, we look into the early history of law we find that very many of these conceptions are unknown. Primitive law may equally well be described as utterly ignoring crime, or as being mainly occupied with it. This paradox means that most of the law of the primitive state had some of the characteristics which today belong only to criminal law, while other characteristics, which today we regard as essential to criminal law, are absent. Thus the acts against which primitive law legislated were, for the most part, acts which were undoubtedly criminal so far as moral guilt was concerned; yet the method by which the primitive law attempted to punish these acts was not by the intervention of the State, but by private action.

Compensation for Murder. The criminal act was not regarded at the early stage as an injury to the State, but only as an injury to the individual. Thus the question of redress was left to the individual. In the earliest times the individual was expected to take the law into his own hands and retaliate upon the criminal. The family of a murdered man should kill the murderer. At a later stage the obtaining of redress is still left to the injured person, but a pecuniary penalty, instead of retaliation, is fixed for each class of crime. Thus, in the Anglo-Saxon laws, a wergild could be claimed by the relatives of a murdered man, and these were neatly graded according to his condition in life, being 1,200 shillings for a thegn, 200 shillings for a villein, 40 shillings for a slave, and less for a Welshman than for a Saxon. A similar scale existed for injuries short of death. Some idea of what these sums represent in twentieth century values can be obtained from the fact that at this time a cow was valued at about a shilling.

When at a later time the State first insists that the penalty shall be payable to itself, and then later realizes that it is the State's duty to interfere for the punishment of crime, even though the injured person does not ask its aid, we still see, in the scale of penalties which it imposes, traces of the earlier attitude. Thus the important question in many cases in fixing the penalty is, what would satisfy the revenge of the injured party? For example, in Roman law, a thief caught red-handed was punished much more heavily than one caught after the lapse of some time, for the law reasoned that the injured person would be likely to exact a greater penalty in the heat of his anger than when his anger had had time to cool. Gradually the older ideas were abandoned as the law progressed, and we finally reached the conception of a crime as an offence against the State and punishable by the State.

LESSON SEVEN

Punishment in Law and Ethics

From what has been said, it follows that it is not every act which is hurtful to the community that is declared to be a crime, and it remains now to consider, first, the principles on which wrongful acts should be singled out for punishment as crimes, and, secondly, the objects and justification of that punishment.

The infliction of punishment causes hurt not only to the criminal but also indirectly to many other persons and when it takes the form of imprisonment it is wasteful and expensive. Thus, before any act is made a crime, the State should be satisfied that the evil caused by the act is greater than the evil necessarily attendant on punishment. Thus, as a general rule, mere lying is not, but lying when under oath is, a criminal offence, because the evil to the community is much greater in the second case—where a man may be wrongfully convicted, or acquitted as the result of lying evidence—than in the first.

Cooperation of the Individual Essential. The act must, further, be one which the State can in practice detect. It has been said that it is impossible to make a nation good by means of legislation, and the statement is true to this extent, that it is useless for the State to attempt to prohibit an act by making it criminal, unless the prohibition can be enforced. Two factors may make this enforcement difficult: first, the act may be one which is usually done under such circumstances that it is impossible to obtain evidence that it has been done; secondly (and this is closely connected with the first), the act may be one of which the community as a whole does not disapprove. It is no doubt the function of the law to raise where it can the moral standards of the community, but the process must be carried out with care. The State cannot rely entirely upon the police for the detection of crime, but must have the cooperation of private individuals. The result of declaring illegal an act which the community does not regard as wrong may be that this cooperation is absent, the law will be brought into disrepute, and the very dangerous idea promoted that a man may commit a criminal offence without doing anything morally wrong.

The recent history of the law of lotteries provides a good illustration of this point. Until 1934 every lottery—even the 6d. raffle at the village sports—was illegal. This total banning of lotteries was not in accordance with public opinion and as a result it was impossible, even if the police did prosecute, to enforce the law. The law, moreover, was ignored by all those participating not only in small lotteries such as the example given, but also in big lotteries such as the Irish sweepstake, where the very large amounts involved made it very arguable that the continuance of these lotteries was not in the public interest. In 1934, however, an Act was passed which brought the law more into accord with public opinion. This Act legalized the small 'private' lottery and restated the illegality of the larger lotteries. The result has been that it is much easier to enforce the law.

Objects of Punishment. Hard though it may be to decide what wrongful acts should be made crimes and which should be left, as civil wrongs, to the redress of the injured parties, the further task of deciding what is the proper basis of punishment for criminal acts is still more difficult. The main object of punishment is to prevent crime, and it may do this in three ways: (1) It may prevent the criminal himself from committing further crimes by detaining him in prison or putting him to death; (2) it may by its example deter other members of the community from committing crimes; (3) it may reform the criminal by giving him such treatment and training in prison that he will refrain from committing further crimes when he is released. These may be described respectively as the preventive, deterrent, and reformatory elements in punishment. The reformatory element is of recent growth. Formerly punishment was purely preventive and deterrent, relying largely on death and mutilation for its terrors; but the prison reform movement which started in England in the early 19th century has so far progressed that in many countries—notably in some American states—reformation of the prisoner is now regarded as the sole object of punishment.

There is, further, still present as an object of punishment, in addition to the prevention of crime, something of the old retributive element of revenge, or the gratification of the feelings of the person who has been injured. This was a very important object in early law, where, as we have seen, punishment was measured by the resentment of the wronged party, and a thief was more severely punished if caught red-handed, because the wronged party might be presumed to have exacted a greater penalty himself than if his anger had had time to cool.

In England, so recently as 1741, an order was made for the hanging in chains of the body of a murderer 'on the petition of the relatives' of the murdered person. This retributive element is condemned today by many, but there is no doubt that there exists in the minds of most members of the community a feeling that 'wrong contradicts right but punishment contradicts the contradiction,' and that it is still an object of punishment 'to adjust the suffering to the sin.' This idea that a criminal should pay for his misdeeds is so deeply engrained in the feelings of a large part of nearly all communities that it is impossible to leave it out of account.

Fitting Punishment to the Crime. The proposition that punishment should be relative to the offence and to the offender would probably meet with as much general approval as can be expected for any general proposition in so controversial a subject. As regards the offences, the relevant considerations would appear to be: (1) the greatness of the evil that might be caused by the act; (2) the ease with which the act can be committed—thus postmen are severely punished for thefts of letters; (3) the prevalence of the particular crime at the time—thus during the Second Great War 'black market' and looting offences were severely punished.

The condition of the offender must next be considered. Was he subjected to great temptation? The effect of temptation will vary according to whether regard is had to the preventive or to the retributive element in punishment. If the only object be prevention, then the greater the temptation the greater should be the punishment, in order that it may act in the future on the mind of the criminal and of others subjected to similar temptation and counteract the great temptation. If the retributive element be regarded—the desire to make the punishment fit the crime—just as the absence of all temptation must make the crime more serious, so the presence of temptation must reduce the moral guilt of the offender. It is this second view that generally prevails, although, as we have seen, when the temptation is great simply because the crime is easy—e.g. shoplifting—this should increase the punishment.

Problem of the Criminal. What are the antecedents of the criminal? Has he ever 'had a chance'? It is obvious that a man who has been forced all his life to live in bad surroundings and associate with criminals should be less severely punished than one who has had the benefit of a good home and education.

How will the punishment affect the criminal personally? Imprisonment will have a more serious effect on the social status of a man in a good position than on that of a labourer; while a labourer will find it much harder to pay a fine. On the other hand, the labourer's family may be reduced to indigence from the loss of his earnings during his imprisonment, while the family of a man in a good position may have other resources.

Is the criminal capable of reformation, or has he already been several times in prison? This again gives rise to difficulties. When a man has a bad prison record, is it to be said that he is incorrigible and therefore, if prison be reformatory only, should not be sent to prison at all? Or is it to be said that he has not reformed, because he has not had long enough sentences, and therefore should be sent to prison for a longer period, as his reformation will obviously take a longer time? Or is it to be said that he will never reform, and should therefore be kept in prison indefinitely out of harm's way?

The above are some few only of the considerations involved in assessing the proper punishment for a crime. At the present time the whole subject is in a state of great confusion. The principles are largely experimental, and their application rests on the wisdom of the particular judge or magistrate responsible for their individual administration. The future will, it is hoped, see some more general agreement on these very vexed questions.

LESSON EIGHT

'Patria Potestas' and Modern Family Law

TODAY the family is a unit with which the law is little concerned, but in earlier times the position was different. It may be that the family was itself a legal centre, the orders of its chief being the equivalent of laws before the State came into existence; and that the early State was a collection of families in which the family remained a unit enjoying for many purposes legal rights and duties as a legacy of its earlier independence.

An immense amount of research has been made in attempts to discover what was the organization of the early family. Some writers have supported a patriarchal theory, others a matriarchal. The view today is that it is probably incorrect to imagine that any one form of organization common to all primitive families ever existed, and that at most it may be stated that in nations belonging to the Indo-European group patriarchy in one form or another was by far the most usual form of organization.

'Patria Potestas' in Ancient Rome. It may be of value, then, to outline the family as we find it in early Rome, where, with its peculiar development of *patria potestas*, it retained for long an extreme vigour. The essence of the Roman system is summed up in the words *patria potestas*—the lifelong authority of the father over the person and property of his descendants. This, however, was limited to the private relationships. So far as public duties to the State were concerned, the father and son were equals, and as such voted in the city or fought in battle. In the private relationships—i.e. in those spheres of activity which had not of necessity come under the control of the State when it was brought into being by the coalescence of a number of families—the father in early times was absolute. He had the power of life and death; he could choose a wife for his son or a husband for his daughter, and divorce either at his pleasure; he could transfer his children to another family by the process of adoption.

These powers over the person of his children were gradually reduced as the State developed; but the powers over property remained until a very late date. Within the family all property was regarded as belonging to the father, and the State never contemplated that the children should ever hold property separately from him. Conversely, the father was liable for any wrongful acts done by the son.

Kinship. Closely connected with the family is the idea of kinship. In Roman law relationship might be either agnatic or cognatic. Cognatic relationship is relationship according to modern ideas—i.e. all persons are related cognatically who are descended from the same pair of married persons. Agnatic relationship is a much more intricate and complex matter. It included all persons who could trace their descent from a common ancestor through males only; descendants of a woman were agnatically related not to the family to which she had belonged before her marriage, but to the family into which she had married. Thus, if we imagine four brothers and a sister; so long as the sister remains unmarried she is related agnatically to her brothers; as soon as she marries she loses her agnatic relationship with her brothers and enters into the agnatic family of her husband. The explanation of this rule is that the agnatic relationship depended on *patria potestas*—all persons being agnatically related who were under the same paternal power, and a woman on marriage passed into the *patria potestas* of her husband or of the head of his family.

Agnatic relationship included also persons who were not cognatically related at all, but who had been adopted. The process of adoption is of very great importance in early law. It consisted of a fiction that a certain person became a member of a family with which he or she was in no way connected in blood. The purpose of adoption was usually to provide the adopter with an heir for purposes connected with ancestor worship and the perpetuation of the family. Ancient adoption thus bears very little, if any, resemblance to adoption as understood today.

When we turn to the consideration of family law as it exists today, we shall find many traces of these early influences, and very many rules still in force which owe their origin and justification to the old theory of the family as a separate unit in the State.

Law of Marriage. Marriage may be defined as a bond between husband and wife which has as its object that they shall live together for life to the exclusion of all other men and women. It is a legal contract, for the parties by entering into it undertake certain obligations towards one another, but in most countries it is also a religious sacrament. Even in its contractual aspect, however, it lacks some of the elements of ordinary contracts. For example, when parties are induced to enter into an ordinary contract by some untrue statement made by the one to the other the contract can be set aside, but this does not apply to marriage; thus if a man induced a woman to marry him by making untrue statements as to his wealth, the marriage is nevertheless valid. Further, ordinary contracts can be dissolved by the consent of both parties, but in this country this does not apply to marriage.

The extent of the religious element legally necessary to marriage varies in different countries. In some no marriage is recognized unless it is solemnized with a religious ceremony; in others all that the State requires is that the parties should go through certain formalities of a non-religious character. In England the law recognizes both a marriage performed in a church and a marriage in a registrar's office. The general policy of the Canon Law—the law of the Church—has been to facilitate marriage and legalize cohabitation whenever possible. This has been followed by the laws of some countries; for instance, marriage in Scotland could take place without any ceremony at all—e.g., until very recently by consent of the parties, or by their living together as man and wife.

Christian and non-Christian countries both recognize certain impediments to marriage. The parties must be of a certain age, the required age varying very much from country to country; they must not be within certain prohibited degrees of relationship. These degrees include persons who are related merely by marriage; thus, until special provision was made by statute in this country, a man could not marry the sister of his deceased wife. The rabbinical law of the Jews always allowed marriages between such persons. In some countries when a marriage has been dissolved on the ground of adultery, the guilty spouse is unable to marry the person guilty of adultery.

Sometimes the consent of certain persons besides the parties is necessary before a marriage can take place. In England persons under 21 are required to have the consent of their parents or guardians, but the absence of this consent does not invalidate the marriage; it merely makes the parties liable to penalties. In Scotland no such consents are required. In some countries the consent is required even though the parties are over 21 years of age. If consent is unreasonably withheld, it is sometimes possible to obtain leave from the court to dispense with it.

Husband and Wife in the Eyes of the Law. In England marriages may be either Anglican or non-Anglican. An Anglican marriage must be celebrated in a church by a clerk in Holy Orders in the presence of two witnesses between the hours of 8 a.m. and 6 p.m. Certain preliminary steps have to be taken in order to secure some measure of publicity; the banns may be formally proclaimed, or a common licence obtained from an archbishop or the chancellor or surrogate of a bishop, or a special licence from the Archbishop of Canterbury, or a certificate from the superintendent registrar. It does not matter which of these methods is adopted. Non-Anglican marriages include marriages performed in some religious house with a religious ceremony other than that of the Church of England and also marriages in a registrar's office. For these the certificate of the superintendent registrar is required.

No step which a human being can take is more productive of legal consequences than that of getting married. The personal freedom and rights of property of both parties are vitally affected. In the last century the movement for equality between the sexes went some way to modify the position, and today husband and wife cannot be compelled to live together against the will of either, nor is the husband entitled to imprison or chastise his wife, although this last question was sufficiently doubtful to require a decision of the Court of Appeal to lay down the law no longer ago than 1891.

Yet the parties, if they live apart, can be compelled to support one another. This duty is heavier on the husband than on the wife. The husband who is cruel to his wife, or who deserts her, or allows her to become chargeable to the poor rate, can be compelled to work in order to earn money to pay for her maintenance, and in practice is in considerable risk of going to prison if he fails to do so. If he does not provide means of support for a wife whom he has deserted she will, in addition, be entitled to incur debts for food and clothing for herself and the children for which the husband will be liable. The wife's liability for the support of her husband is, as has been said, not so extensive. She will, however, be liable when her husband has become chargeable to the poor rate, but the liability is limited to her property, i.e. her earnings cannot be touched, so that she has no duty to work to maintain him.

Liabilities of a Husband. Until 1882 a man on marriage became the owner of all his wife's property unless it had been specially settled on her, and had an equivalent—perhaps in the circumstances not unfair—liability for many of her contractual debts and for any acts committed by her amounting to torts or civil wrongs. A husband's right to his wife's property has been abolished, and also his liability on account of most of her debts and civil wrongs. A husband is still liable in most cases for clothes ordered by his wife necessary to his station in life or for household supplies, and until 1935 he was further liable for her civil wrongs: e.g. if she were negligent in driving his motor-car and injured any person, or by indiscreet and scandalous conversation committed a slander on the reputation of another. In 1935 a great deal was done to place a married woman in the same position legally as men and single women. She can now be made bankrupt in the same way as other persons (previously she could be made bankrupt only if she was engaged in some trade or business).

We have seen above that the law imposes on the husband a duty of maintaining his wife during his life. It is somewhat remarkable that until 1938 the law made no similar provision applicable after his death. A man at his death could by his will deprive his wife of the house she had lived in with him and the home surrounding her, and leave her penniless. The Inheritance (Family Provisions) Act 1938, which came into force on July 13, 1939, gave to the court power, when any man (or woman) in a will omitted to make 'reasonable provision' for his wife (or her husband) or other 'dependants,' to order reasonable provision to be made out of his (or her) estate. 'Dependants' includes not only the surviving widow (or widower) but also any son under 21, or unmarried daughter, or any son or daughter who is incapable of maintaining himself or herself because of some mental or physical disability. The right to a reasonable provision is subject to several restrictions, and the court is entitled to take into account the reasons why the deceased has not made provision for his dependants. It will be noticed that the right is not confined to widows. A widower is entitled to claim 'reasonable provision' for his maintenance out of his late wife's estate. Obviously only in exceptional cases will a widower's claim be upheld. One curious result of the new law is that in some cases wives have become reluctant to divorce their husbands, particularly if the wife is young and the husband elderly, because after the divorce they naturally cease to be 'wives' and so lose all rights they might otherwise have had to make a claim under this act.

Judges have found the provisions of the act difficult to apply, as it does not give them unlimited power. An act giving 'dependants' the right to a fixed proportion of the deceased's property or giving the court full power to order any provision it thought reasonable in each particular case would have been much simpler to administer.

Scots law has always contained a hard and fast provision entitling a widow (or widower) to half the spouse's 'personal' property if there are no children, and to one third if there are children. The children are also entitled to a third.

Annulment of Marriage. In certain circumstances, one of the parties to a marriage can have the marriage annulled—i.e. declared void ab initio; can obtain a divorce; or a judicial separation. A marriage is declared void (i) when there has been some irregularity in its celebration; (ii) when the parties are within the prohibited degrees of relationship; (iii) when one of them is under the minimum age at which marriage is allowed (in England at present sixteen); (iv) when one of them is physically impotent or (v) was married to some other person at the time of the 'marriage.' An act introduced in 1937 by Mr. A. P. Herbert made annulment of a marriage possible at the instance of one party on the following further grounds:—(i) where it has not been consummated owing to the wilful refusal of the other party; (ii) where the other party was at the time of marriage insane or a mental defective or subject to fits of insanity or epilepsy; (iii) where the other party was suffering from venereal disease at the time of the marriage. The husband can also sue for annulment where, unknown to him, the wife was pregnant by some other person at the time of the marriage.

Divorce and Judicial Separation. A divorce puts an end to marriage without making it void ab initio. The grounds on which divorce is granted differ very greatly in different countries. Divorce as such is unknown to the Catholic Church. In America the law on divorce differs in different states, and in some of the states very slight grounds are held sufficient to justify a decree.

In England and Scotland the divorce laws have recently been very much widened and in both countries the main grounds for divorce now are adultery; cruelty; incurable insanity; and desertion for a minimum of three years. On the other hand, in England, save in very exceptional cases, divorce proceedings cannot be started until three years after the marriage.

Judicial separation was formerly important as, though it does not end the marriage, it put the wife, so far as her property and her husband's liability for her debts were concerned, in the position of a single woman. Today, as her property is not affected by marriage nor is her husband liable for her acts, judicial separation is not of great importance. Where, however, grounds for divorce have arisen, but it is not possible to take divorce proceedings at once because the parties have not been married for three years, proceedings for judicial separation (to which the three-year rule does not apply) are sometimes brought. This makes it easier to obtain a divorce when the three years have elapsed. A decree of judicial separation can be obtained by either party on any grounds on which a divorce could be obtained. Parties may always separate under a separation deed on such terms as they please.

Law Affecting Children. In every country distinction has been made between children who are 'legitimate' and those who are 'illegitimate.' This has always been necessary for purposes of succession to property, for illegitimate children are nearly always excluded. In England, until 1926, legitimate children could be defined as 'children born in lawful wedlock,' and no husband or wife is allowed to give evidence to the effect that a child born during the marriage is not legitimate. Since 1926, however, it is possible for a child which has been born illegitimate to be later legitimated by the subsequent marriage of its parents. This is part of the Roman Law and has survived in Scotland. The child can be legitimated only if at the time of its birth its parents were free to marry, and will thus not be legitimated if one of them at that time was married to some other person.

In 1926 also legal adoption was introduced into this country. We have seen that adoption was an important feature of early Roman Law and of other early legal systems, but the purpose it served there was connected with the conception of the continuity of the family, and an adopted child became part of the adopting family for all purposes. Adoption in modern times is for a different purpose. Until 1926 it was not easy for a natural parent to give up his or her rights in the child, and any person who 'adopted' the child by taking it to live with him or her might be unable to prevent the natural parent reclaiming the child at a later time. Further, the adopting parent was not bound to support the child, which he could abandon at any time. It is now possible to get an order of the court divesting the natural parent of all rights and duties and vesting these in the adopting parents. The child acquires no rights to succeed to any of the property of the adopting parent on intestacy. An act of 1939 (brought into full force in 1943) made stringent rules to prevent abuses connected with adoption.

A father is liable to support his children under the age of 16, and also over that age if they become chargeable to the poor rate and he has sufficient means. If the father is dead the mother is liable. The parents have rights over the persons of their children, but none over their property.

LESSON NINE

The Law of Property

The word 'property' is difficult to define, largely because we are accustomed to use it in two distinct senses. First, we speak of 'a man of property,' thinking of the material things the person owns—a house, furniture, land, jewelry, and motor-cars—and also of various other rights not over tangible things like the above, but rights to shares in limited companies or to sums of money owed to him by his debtors. We say that all these things are the 'property' of the person because he owns them and can do as he likes with them. Secondly, we also use the word to define not the things themselves, but the nature of the rights exercised over them, as when we talk of rights of property.

In most countries the State has allowed individual citizens to appropriate to themselves the things which make up property, and has passed laws to prevent others from interfering with them in the enjoyment of their property. The rights thus conferred on the citizens may be called 'proprietary rights.' The idea of the individual owning property to the exclusion of others is of great antiquity in the laws, not only of this country, but of nearly all civilized states, though the idea is not found in the earliest period of which history has knowledge. In those early days, when the tribe has not yet passed into the State, we find that the property is owned by the tribe as a whole and not by the individual members. We still find this in the laws of England before the Norman Conquest, when land is cultivated and enjoyed in common by the inhabitants of a village. In recent years we have in the socialist and communist movements a tendency to abandon the system of individual ownership in favour of communal ownership by the State. In Russia this change has, with the exception of ownership of personal property, been effected in its entirety; but in other countries it is only partial—e.g. extending only to the property of some or all of what are regarded as essential services, such as the post office, the railways, lighthouses, docks, etc.

Ownership and Possession. It may be of advantage here to distinguish between ownership and possession. Ownership, as we have seen, is a question of legal right; possession is a question of fact. A motor-car may be owned by one person; he may lend it or hire it to another. The first person will remain owner, but, when the lending or hiring takes place, he will lose the possession of the motor-car. At the end of the period of lending or hiring, the owner will regain possession when the motor-car is returned to him. Although possession is, as we have said, a matter of fact, it is a fact of great legal importance, for the maxim, 'possession is nine-tenths of the law,' has a great deal of truth in it. Possession is evidence of ownership, and when we examine into the rights upon which the ownership of any property is based we shall find that, in their origin, they rest upon the fact of possession.

Thus, if A were asked to prove his title to a piece of land, he would probably do so in the first place by producing a conveyance from X to himself. If the title of X were similarly examined, he would rely upon a conveyance from Y, but in the end there would come a stage at which some remote predecessor in title of Y must be presumed to have owned the land because he was in possession of it. This evidence of possession would not be conclusive, for it would be open to any person to show that the possession was wrongful—i.e. was that of a trespasser.

In addition to being evidence of ownership, possession is also protected by law as a right distinct from ownership. Thus a person who has a hired chattel—such as a motor-car—can sue for damages if he is deprived of the possession of it; and, if the chattel is stolen from him, he can prosecute the thief, although the chattel is owned, not by him, but by another.

Classes of Property. Property, as we have considered it, falls from its nature into three classes: first, land, which is immovable and fixed in one place; secondly, chattels, corporeal things which can be moved from place to place; thirdly, rights of a more vague character, such as shares in a company, or sums of money owed by others to us. These last are not tangible things; for although we may handle a share *certificate*, the certificate is not the property, but merely evidence that the share represented by the certificate is owned by us, in the same way that title deeds to land are evidence that the land belongs to us. Property of this intangible character is usually referred to as an incorporeal movable. Though this threefold division of property is recognized almost universally, yet for practical purposes the most important division is between property which is immovable—i.e. land—and property which is movable—i.e. corporeal and incorporeal movables, which are usually classed together.

In English law property is divided on these principles into real property and personal property. The division is not of merely theoretical, but also of great practical importance (though less important in England since the passing of the Property Acts of 1925, discussed below), for on it will depend the legal rules which govern the method by which the property may be transferred, and the persons entitled to succeed to it on the death of the owner intestate. Thus, while the ownership of a motor-car may pass from one person to another by a mere oral agreement for its sale, even though the *possession* remains in the seller, the ownership of land must be transferred by a written document, and the ownership of shares by a written transfer followed by registration in the company's books.

It is impossible to understand the English law of real property today without some considerable knowledge of its history, i.e. of what the law has been in the past.

Real Property. The simple division into movables and immovables has not been maintained. Real property originally meant property which the owner could recover from any person who deprived him of it, whereas if a man were deprived of personal property he could not recover the actual property itself, but must be satisfied with a sum of money as damages for his loss. Feudal law would not allow all the interests it created in land to be specifically recoverable; so it was that some interests in land were real property, while others were personal property. Estates for life or greater interests were real property, but leases, even if for 999 years, were personal property, because originally they had not been specifically recoverable.

No one in England could own land except the king. All other persons were tenants holding on some tenure some estate or interest in the land, either direct from the king or through some intermediate tenant holding from the king. This system of tenure was essential to the feudal system. The tenant rendered to his lord certain services for the estate he held. There were originally four kinds of free tenure distinguished by the different services which the tenants were required to render. A tenant in knight service was bound to do military service; a tenant in frankalmoign, religious services; a tenant in sergeanty, personal services; and a tenant in socage originally performed specified work on the lord's land, and later paid a money rent. With the decay of the feudal system the majority of these tenures became obsolete, and in 1660 all tenures were turned into socage, with the payment of rent. Side by side with these free tenures existed unfree tenure, or copyhold, the copyhold tenant holding by virtue of the court roll of some lord's manor.

Land Tenures. There might be several tenants all holding different 'estates' in one piece of land. Thus, A might be tenant in fee simple, B tenant in tail, and C tenant for life. A would hold an estate which entitled him to dispose of the land to anyone he wished, and on his death the land would pass to his heir, even if that heir was some collateral and not a direct descendant. B had an estate which could descend only to his descendant; if he had none, then the estate came to an end. C's estate must come to an end with his own life. Of course, only one person could be in possession of the land —the tenant for life in the illustration taken —and the other tenants merely stood by, ready to come into possession on the termination of the estate before them. Thus, on C's death, B would take possession, and if at any time B's heirs in the direct line failed, A or his successors in title would take possession. C was said to have an estate in possession, and B and A to have future estates. Other estates could be created, e.g. it might be provided that A should hold land until he married and that then the land should pass to C.

Property Acts 1925. For many years before 1925 the only feature of tenure which remained was 'escheat,' that is, the rule that when a tenant died without any persons entitled to succeed to him his estate escheated to his lord. Since 1290 it had not been possible to create any new tenures, so that the result of escheat had for long been that the land passed to the Crown as the lord of the tenant. A series of statutes in 1925 revolutionized the law of real property in this country.

These Acts had two objects: (1) to get rid of artificial distinctions between land and movable property, and (2) to simplify dealings in land. Until 1925 real property had passed on intestacy under rules entirely different from those governing personal property. The law has now assimilated the two, and has provided rules so that on a man dying intestate his property will pass to the persons he would probably have wished to have it if he had made a will. A model will has in fact been made for those who omit to make one of their own. It should be pointed out that this in no way interferes with a man's right to dispose of his property by will as he pleases, but applies only where he dies intestate. The general principles of estates in land have also been greatly simplified, and future interests in land must now be created by means of a trust—thus further assimilating the law of land to that of movables. Again, before 1925 real property was liable in a different order from personal property for the debts of a deceased person; now both are governed by the same rules.

Personal Property. Personal property included all movable objects, commonly called chattels, but it also included leases for a term of years—very valuable rights, but not recognized as 'estates' by the common law.

The reason for this is of considerable interest. In the Middle Ages, when the lease for a term of years was first introduced, trade and industry in the form in which we have them today were unknown; a person possessed of money who wished to invest it so that it might yield him an income could buy no stocks or shares in limited companies. A lease of land which could be sub-let to others at a money rent was the only form of investment. Now at this time the law imposed many inconvenient restrictions on real property, and so the new moneyed class did not desire that this popular investment—a leasehold—should be regarded as real property and so subject to these restrictions. Accordingly it became personal property for a reason very important in law—the pressure of powerful and interested public opinion. Lawyers felt that this new accession to the ranks of personal property had little in common with the ordinary chattel property of the time—furniture, cattle, and horses—so they invented for it a new name, a chattel real: a name sufficiently confusing, for a leasehold was not a chattel nor was it real property.

Chattels Corporeal. We have seen that the only person who could own land was the king, and that all other persons interested in the land were tenants. No such rule ever applied in the case of chattels, nor did the law ever recognize estates in chattels similar to the estates in land. The chattels known to the early law were all chattels corporeal—easily destructible and lacking the permanence of land. To a certain extent, however, the law did recognize a division of interests in chattels; it was always possible for the ownership to be in one person and the possession in another. The person in possession—known as the bailee—was given extensive rights for the protection of his interests. He could sue any person who deprived him of the goods or who damaged them, and could recover damages irrespective of whether or not he was liable to his 'bailor.' Thus, if a motor-car is hired by one person from another, and is damaged by the negligence of a third person, the 'bailee' can sue for the damage even if he is not liable to the 'bailor.'

With the exception of precious stones and metals, chattels proper (i.e. 'corporeal') must always be of comparatively small value.

Chattels Incorporeal. There is, however, another class of chattels known to the law today which forms by far the greatest part of all wealth. This is chattels 'incorporeal,' and it includes such intangible things as debts, negotiable instruments, shares, stocks, and debentures. A share certificate, it is true, is a chattel corporeal when regarded as a piece of paper; but when regarded as a share certificate it is merely evidence that the person whose name is on the certificate is entitled to certain rights as a shareholder in a company according to the regulations of the company. It is these rights which are of value and not the piece of paper.

It is not possible from their nature to separate the ownership of chattels incorporeal from the possession. Nor is it permissible to create 'estates' in them as in real property, although very much the same result may be reached by the use of trusts. Thus shares may be given to trustees on trust to pay the dividends on them to A during his life and after his death to hand over the shares to B. A and B will here be in much the same position as if A had an estate for life and B had the fee simple in reversion.

The ownership of these various classes of property is transferred from one person to another in different ways. Real property and chattels real can be transferred only by a written conveyance; chattels corporeal are usually transferred by delivery, and chattels incorporeal by a written instrument—in some cases requiring registration or intimation. As is so often the case in law, there are exceptions to some of the above rules. Thus in England on the sale of chattels corporeal the property may pass before delivery, while the goods are still in the hands of the seller. This is not universal, and in many countries the property does not pass until delivery.

The distinction leads us to a matter of great practical importance. It is a fact that the financial stability of any person is frequently judged by the chattels he possesses, and he may be given credit on the basis that since he possesses the chattels he is also the owner of them. Further, one person may buy goods from another under the impression that the goods belong to the seller because they are in his possession. Since possession is thus so frequently made the practical test of ownership, the law has endeavoured to protect those who give credit to a person in possession of goods or who buy goods from a person which he appears to be entitled to sell. In some countries, e.g. Scotland, it is impossible for any person to give to another a charge over chattels in security for a debt unless the possession of the chattel is also transferred to the creditor; in other countries, e.g. England, a less complete protection is given by requiring that all such transactions shall be registered and so made public. Thus in England every such transaction must be registered as a bill of sale in a register open to public inspection. Further, when a man becomes bankrupt, property in his possession and used by him in his business may be available for the payment of his debts, even though it belongs to some other person.

Buying and Selling. The problem of protecting innocent purchasers is a more difficult one; but English law provides that where goods are sold and are allowed to remain in the possession of the seller after the property has passed, or are allowed to pass into the possession of the buyer before the property passes, then a sale by the seller or buyer, as the case may be, to an innocent third person will convey a good title to that person. Protection is also given to persons who buy from 'mercantile agents'—i.e. dealers—who have goods in their possession and who fraudulently sell them.

LESSON TEN

Applications of the Law of Contract

THE law of obligations is divided naturally into 'contracts' and 'civil wrongs.' A person may by his own voluntary act, i.e. by entering into a contract, acquire rights and duties towards other persons; such obligations are contractual. Without any voluntary act, however, every person owes duties to others arising not from contract but from the needs of society. Thus the driver of a motor-car owes a duty to other road users to exercise reasonable care in his driving, and everyone owes a duty to others not to libel them. A breach of these duties is a civil wrong.

A contract requires an agreement between at least two parties. The agreement must, further, be intended by the parties to affect their future conduct; thus if A and B agree that the Battle of Hastings was fought in 1066, there is undoubtedly an agreement between them, but no contract. Further, the agreement must be one which is intended by the parties to affect their legal position and have a legally binding effect. If A asks B to dinner on a certain date and B accepts, there is a binding agreement as to future conduct, but it cannot be said that A and B contemplated that if B should not keep the engagement he should be liable to any legal action. The parties to the agreement were making a social arrangement not intended to affect their legal positions. Again, the agreement must be one which the law will enforce. The law may require the agreement to be in a certain form, e.g. in writing, or to have some special feature, e.g. consideration in English law. In other cases the law may refuse to enforce a contract, even though it has the necessary elements, because it is against public policy, e.g. a gambling contract in England.

From Status to Contract. In early law, when trade was small, society managed to carry on its affairs without entering into relationships which we should now consider contractual. Persons had rights and duties, not because of any agreement into which they had entered, but because of the status they held in society. Thus rights which a master had over his servant did not arise out of any contract between them, but out of the relationship of master and servant itself. Sir Henry Maine has expressed this in a formula which has become famous, by saying that the development of the law has been 'from status to contract.'

In recent times freedom to make contracts has in a great many matters been restricted, and persons entering into agreements must accept some code of rights and liabilities applicable to them because of the relationship into which they have entered. For instance, wages boards, set up under the Trade Boards Acts of 1909 and 1918, have established minimum legal rates of pay in certain industries; ever since the First Great War the Rent Restriction Acts, which limit rents and prevent tenants from being evicted, have applied to a large number of houses in this country; in 1938 an act empowered wages boards to award holidays with pay to employees whose wages they regulated, and so on.

Of late years legislation has established government control over many of the great industries of the country—e.g. agriculture and coal-mining. For our present purpose, the importance of these various legal enactments lies in the fact that they are compulsory and cannot be altered by agreement of the persons to whom they apply. Such state control increases during time of war, and the tendency is for wartime controls to become permanent.

In early times, however, we find neither the state control with which we are now familiar nor our modern conception of contract.

On the rare occasions on which a contract was required, it assumed invariably a semi-religious form, with the parties making vows to perform their obligations, the duty being regarded as being owed to the Deity rather than to the other party to the contract. Here the form of the contract was the essential part, the parties having to use the precise formal words of the ceremony. Even when contract began to lose its religious character the formalities remained, and the important question in any contract was not 'what was the intention of the parties?' but 'what forms did they go through?'

Furthermore, it was not open to the parties to contract on any matters that they pleased. There were certain recognized contracts—e.g. hire or sale—into which they could enter with certain well-defined consequences, reminiscent perhaps of the idea of status; but to contract on other matters was not possible. As trade expanded, this limited contractual power became increasingly inadequate, and gradually in each country a more extensive system of contracts was developed. In England the formal contract had been the contract under seal to which the parties, in the days before writing was a common accomplishment, affixed their seals instead of their signatures.

The Doctrine of Consideration. When the law expanded, the courts in England refused to hold that every promise given was binding as a contract, and would not recognize a contract unless the person who was seeking to enforce a promise by the other party had himself undertaken some obligation in the contract towards that other party. This mutuality was called consideration, and may be defined as some benefit given or promised by A, or loss or liability incurred by B in return for A's promise. Thus if A promises to lend B his horse for the harvest and B, in return, promises to give A some part of his wheat, there is a good contract. If, however, A had promised to lend B his horse and B had promised nothing in return, B could not compel A to lend the horse.

This doctrine of consideration is so essential a part of the law of England that it is sometimes difficult to realize that it is not the law of all countries, and that in many cases it works definite injustice. No similar rule has ever existed in Scotland, and, on principle, it is not easy to see why a promise made and relied upon should not be enforceable. Lay opinion generally tends to regard such a promise as binding. For example, if A and B are negotiating for the sale of a house and A offers to sell to B for £2,000, B may say that he is unable to accept or refuse the offer at once, and A may then say he will give B a week to think the matter over and meantime will not sell to anyone else. There is no consideration for this promise to keep the offer open, and if A sells the house to C before the week has elapsed B cannot legally complain. Again, X owes Y £100. Y thinks there is little chance of ever getting the full amount, so he agrees with X to take £60 in full settlement. Here, again, there is no consideration, for Y does not get any new benefit, and Y, after getting £60, may sue X for the balance.

Although this is the legal position, B and X will, however, certainly think that they have been unfairly treated, and in 1937 the Law Revision Committee, made up of judges and other eminent lawyers, recommended that the doctrine should be largely abolished.

When Contracts are not Binding. Since the binding effect of a contract is now generally recognized as depending on the mutual consent of the parties, it is not surprising to find that, where this consent on one side is not free and genuine, the contract is not binding. Mistake of the parties may have this effect if it is mutual and relates to a material part of the contract.

Thus, if A agrees to sell to B a cargo of wheat on a ship called the 'Peerless,' and if there are two ships of that name, A thinking of one and B of the other, the parties are both mistaken as to the subject matter of the contract, which is thus of no effect. Mistake by one party only is not sufficient to upset a contract, unless the mistaken party is led into his mistake by the other party. Thus, if A buys a picture from B, mistakenly thinking it is by Rembrandt, and B does nothing to lead A to make the mistake, the contract is good; if, however, B tells A the picture is a Rembrandt, the contract may be set aside. Similarly, if a person is compelled to enter into a contract by duress, or induced to enter into it by an untrue statement made by the other party, his consent is vitiated.

There are two ways in which the law may compel a person to observe his contractual obligations. First, it may compel the party to perform what he has promised to do; secondly, it may, instead, compel him to pay a sum of money as damages to the other party, the amount of the damages being what the other party has lost through the non-performance of the contract. English law is unwilling to adopt the first course in any case where damages can compensate the other party. In some cases they obviously cannot. Thus, if A agrees to sell to B an antique snuff-box used by Prince Charlie, no sum of money which A could pay B would enable him to buy another similar snuff-box, and the court would order A to hand over the snuff-box to B. In certain other cases, however, even where damages would not compensate completely, the courts will not order the carrying out of the contract. So if A agrees to work for B as his secretary and then refuses to do so, the court would award damages, but would not compel A to act as secretary.

As a general rule, the result of a breach of contract will be that damages will be awarded. The object of these damages will be to put the injured party in the same position as if the contract had been carried out. So if X agrees to sell to Y a motor-car for £100 and fails to do so, and if Y could have bought a similar car elsewhere for £120, the damages will be £20. Cases may arise where Y's damage is in reality greater than this. Thus, if Y has arranged to resell the car for £150 and through X's failure to deliver the car has lost the resale, he will actually have lost £50. He will be able to recover this from X only if he told X of the prospective resale at the time of the contract.

LESSON 11

Civil Wrongs in English Law

Civil wrongs are breaches of rights which arise not from agreement but from the common law. The law of civil wrongs is at once of much greater antiquity and less fully developed than the law of contract. We have already seen, in dealing with crime, that in primitive law the idea of a crime as an offence against the State is unknown, and in its place we find acts which we should today consider criminal treated as we should today treat civil wrongs. Thus, a man who has been assaulted by another is either, in very early times, expected to exact revenge himself, or, in a slightly later age, may take the matter to the courts, where he will be awarded a money sum varying with the nature of his injury. This latter system has much more in common with the modern law of civil wrongs than with the law of crime, for the act is regarded as an offence against the individual injured and not against the State.

Acts which are crimes may also be civil wrongs—that is, they infringe the rights of the individual as well as those of the State. When goods are stolen, for example, the thief may be prosecuted by the State and also sued by the owner for damages. One great distinction between crimes and civil wrongs is that in a crime it is essential that the criminal should have had in his mind a criminal motive. To constitute a civil wrong, however, no such motive is required. Thus, if A takes B's overcoat from his club, the act will be a civil wrong, whether A knew it was B's coat or whether he took it in mistake for his own. But it will not be a crime unless A took it knowing it to be B's and intending to deprive B of it.

A breach of contract may also be a civil wrong, for persons may enter into a contract and specify under the contract rights which they have already at common law. Thus, A may hire his motor-car to B and stipulate in the contract that B shall return it whenever asked. If B fails to do so he may be sued for either breach of contract or civil wrong.

Classifying Civil Wrongs. We have seen that the law of contract at one time recognized only certain specific contracts—such as sale and hire—and that by a later development a general law of contract grew up. The law of civil wrongs, however, has never succeeded in emerging from the earlier stage, and thus in England today we have no general law of tort, as a civil wrong is called, but merely a series of acts recognized as civil wrongs without any general principle of liability. If a person has been injured by the act of another he can recover damages only if he can show that the act constitutes one of the known civil wrongs. There is no principle which will enable us to distinguish between acts which are regarded as civil wrongs and those which are not. If A is employed by B, and C induces B to dismiss A without proper notice and, therefore, so as to break the contract between A and B, A will have an action against C; but if C merely induces B to dismiss A *with proper notice*, A has no remedy. Again, if A induces B to revoke a legacy in his will in favour of C, C has no remedy. If the question were asked, 'Why has C a remedy in some cases but not in others?' the only answer that can be given is the very unsatisfactory one that English law has recognized some injurious acts as civil wrongs but not others.

The civil wrongs known to English law may be classified roughly under three heads. First, there are certain acts, innocent in themselves, which a man does, as it is said, 'at his peril'; and if damage results from them he is liable, regardless of whether or not he has taken every step possible to prevent damage. Secondly, there are acts which cause injury for which a man is liable only if he has failed to take proper precautions and exercise care. Thirdly, there are acts for which a man is liable only if he did them deliberately or with the intention of injuring the person who has, in fact, been injured.

Examples of the first class arise where a man keeps upon his land something of a dangerous character, such as a wild animal or a reservoir of water. There is nothing illegal in keeping these things, but if by any chance the wild animal escapes or the reservoir bursts and damage is caused to any person, the owner will be liable, even though he can show he has taken every possible precaution against the event which has happened. Animals which are not wild, e.g. dogs, are in a peculiar position. The owner is not liable if his dog bites some person, unless he knew the dog was dangerous and likely to bite human beings, and in order to prove this knowledge it will usually be necessary to prove that the dog had previously bitten some person. Thus, it is true to say, so far as human beings are concerned, that a dog is entitled to one free bite. Special provision dispensing with this free bite has been made by statute in cases where the dog has bitten an animal such as a sheep, and not a human being.

Acts of Negligence. The second class of acts mentioned above is very wide, and covers what is known as liability for negligence. By no means every act of 'carelessness' in the popular sense is 'negligence' in law. It must first be established that there is a duty to take care recognized by the law. Negligence has thus been defined as a failure to exercise in one's conduct the degree of care *required by the law*. This cannot be said to be a satisfactory definition, but it does make it clear that a person may be careless and so cause damage to others and yet not be liable, unless the law imposes on him a duty to exercise a certain degree of care to the persons injured.

The defect in the definition is that it still leaves to be answered the question: 'In what cases does the law impose a duty to take care?'—and the answer is not easy. The most satisfactory answer to this question is to be found in a speech delivered in a famous case in 1932:

> The rule that you are to love your neighbour becomes in law, you must not injure your neighbour; and the lawyer's question, 'Who is my neighbour?' receives a restricted reply. You must take reasonable care to avoid acts or omissions which you can reasonably foresee would be likely to injure your neighbour. Who, then, in law is my neighbour? The answer seems to be—persons who are so closely and directly affected by my act that I ought reasonably to have them in contemplation as being so affected when I am directing my mind to the acts or omissions which are called in question.

This statement of the circumstances in which a legal duty to take care arises is of outstanding importance. Its application is, however, seriously restricted by earlier decisions of the courts which are still binding.

In the case from which the above extract is taken, a woman had drunk part of a bottle of ginger-ale which a friend had bought from a retailer. The bottle contained a dead snail, and the woman became seriously ill. She sued the manufacturers of the ginger-ale who were held by the House of Lords to be under a legal duty to take reasonable care that their ginger-ale was not injurious to health. In other words, the woman was a 'neighbour' within the meaning of the above legal statement.

In a later case a builder sold a house to a Mr. A. It was so badly built that the ceiling of one of the rooms collapsed and injured A's mother. On general principles, one would suppose that a person putting on the market a dangerously-built house owes a duty to those who may live in it just as great as that which a person manufacturing ginger-ale injurious to health owes to persons who later drink it. The court, however, had to hold that the builder was not liable and owed no such duty because the House of Lords had decided thirty years earlier that no such legal duty existed with respect to a dangerous house. Had it not been for this earlier decision, the courts might well have followed the general principle laid down in the 'snail' case. At any rate, they were prepared to apply the general principle to a person who carelessly erected a tombstone (to which the 'dangerous house' case decided by the House of Lords did not of course apply) which fell and injured a person in the churchyard.

Acts with 'Malice.' The third class of acts is comparatively small, for the motive with which an act has been done is not usually material in considering whether or not it is a civil wrong. In some cases it is necessary, however, that the act should have been done, as it is said, with 'malice.' Thus, to bring an unsuccessful criminal prosecution against a man may cause him much damage and mental suffering, but if the prosecutor had reasonable grounds for prosecuting, no action will lie. He may, however, be sued when his motive has been merely in order to cause injury to the person prosecuted.

It is not possible here to go in detail into various specific wrongs recognized by English law, and it must be enough to say that their general object is to protect property from being damaged or interfered with, to protect a man's person from being injured and his reputation from being attacked.

LESSON 12

The Courts of the English Legal System

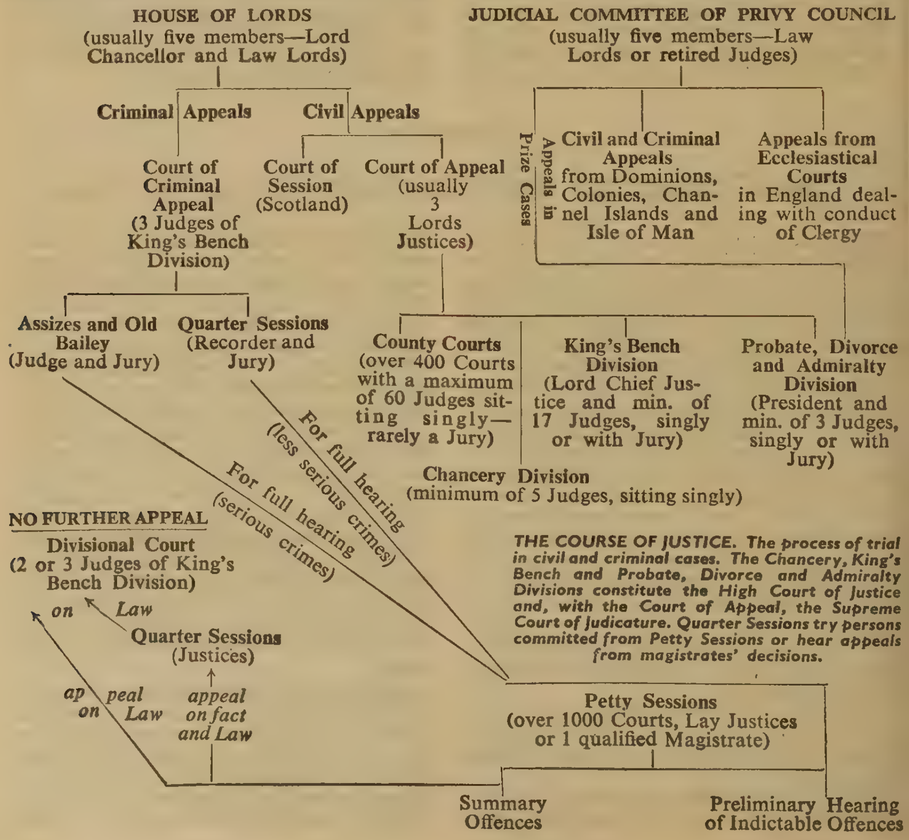
WHILE the legislature is the representative of the State appointed to make the laws, the judges in its courts are its representatives for the purpose of administering these laws by (1) settling disputes between subjects and (2) punishing offences. The first is called the civil and the second the criminal jurisdiction. The above division of functions between the legislature and the courts is one that is observed in England; but in many countries the division is not so clear, and we find in some cases that the courts have usurped part of the power of the legislature, and either have power to make laws, in addition to administering the law as made by the legislature, or else have the negative but equally effective right of declaring that some law made by the legislature is not a good law, but is *ultra vires*, because it conflicts with some written constitution under which the legislature derives its powers.

The courts of the United States have a negative right of this kind, and the subject is more fully discussed in a later Lesson (*see* p. 472).

In this country the courts cannot declare illegal any law made by Parliament, and must confine themselves solely to administering the law as they find it. In one case it would appear that the courts do, in fact, make laws—'judge-made law,' as it is called. Thus, where a set of facts arises which is not governed by any statute or by any principle of the common law which has yet been judicially laid down, the judges before whom the case is heard will decide it in the way which is most in accordance with the general principles of English law and their own common sense. In doing so, however, the theory is they are not adding any new principle to the law, but are merely 'declaring' and making public a principle which has been part of the law for all time. Should their decision be overruled, the result is not that the law has been changed, but merely that the court which has been overruled made a mistake and declared the law wrongly.

Independence of the Judiciary. We have said that the judges are the representatives of the State. In some countries they are more than this, and are actually the servants of the State and part of the Civil Service. In England there is at the present time almost a conflict between the two systems. The judges of the High Court are not the servants of the State, for they hold office during good conduct, and can be removed only by a joint address of both Houses of Parliament to the King. This gives them two advantages. First, they can give their decisions without fear of dismissal should the decisions not be in accordance with the political views of the executive at the time; secondly, their impartiality is secured when, as frequently happens, they are called on to decide disputes between the State and a subject. It has long been the practice, however, and one which has become increasingly frequent of recent years, for Parliament to remove questions arising under Acts of Parliament from the decision of the ordinary courts and to make some department of State—which, in practice, means a clerk in the ministry in question—the sole judge on any question arising under the act. An example of this practice is to be found in the Road Traffic Act 1930, under which many questions are decided by the Minister of Transport.

Trial of Criminal Cases. The courts proper in England are divided into those trying criminal and civil cases. Serious criminal cases are tried by royal commissioners, who are usually judges of the High Court, at the assizes in the shire town of the county in which the crime was committed, or by specially appointed judges at the Central Criminal Court (better known as the Old Bailey) if the crime was committed in the London area. In either case, the prisoner will be tried by a jury, which decides as to his guilt or innocence, under the direction of the judge. If he is found guilty the judge, without the assistance of the jury, decides what is the appropriate punishment. An extensive jurisdiction in all but the most serious crimes is also exercised in each county


HOUSE OF LORDS
(usually five members—Lord Chancellor and Law Lords)
Criminal Appeals
Civil Appeals
Court of Criminal Appeal (3 Judges of King's Bench Division)
Court of Session (Scotland)
Court of Appeal (usually 3 Lords Justices)
JUDICIAL COMMITTEE OF PRIVY COUNCIL
(usually five members—Law Lords or retired Judges)
Prize Cases
Appeals in
Civil and Criminal Appeals from Dominions, Colonies, Channel Islands and Isle of Man
Appeals from Ecclesiastical Courts in England dealing with conduct of Clergy
Assizes and Old Bailey (Judge and Jury)
Quarter Sessions (Recorder and Jury)
County Courts (over 400 Courts with a maximum of 60 Judges sitting singly—rarely a Jury)
King's Bench Division (Lord Chief Justice and min. of 17 Judges, singly or with Jury)
Probate, Divorce and Admiralty Division (President and min. of 3 Judges, singly or with Jury)
Chancery Division (minimum of 5 Judges, sitting singly)
For full hearing (less serious crimes)
For full hearing (serious crimes)
NO FURTHER APPEAL
Divisional Court (2 or 3 Judges of King's Bench Division)
on Law
Quarter Sessions (Justices)
appeal on Law
appeal on fact and Law
Petty Sessions (over 1000 Courts, Lay Justices or 1 qualified Magistrate)
Summary Offences
Preliminary Hearing of Indictable Offences

THE COURSE OF JUSTICE. The process of trial in civil and criminal cases. The Chancery, King's Bench and Probate, Divorce and Admiralty Divisions constitute the High Court of Justice and, with the Court of Appeal, the Supreme Court of Judicature. Quarter Sessions try persons committed from Petty Sessions or hear appeals from magistrates' decisions.

by Quarter Sessions. These consist of justices of the peace, who receive no remuneration and have no legal training. They are, in practice, largely governed by their chairman, who is often a trained lawyer and who performs the duties performed by a judge in other criminal courts. There is also a jury, which is, as before, the judge in questions of fact.

A very large number of minor crimes —legally known as summary offences—are tried by Petty Sessions, consisting, except where there is a stipendiary magistrate (a trained lawyer), of the justices of the peace. Here, however, they sit without any jury or any professional lawyer as chairman; and we thus have the astounding result that, in English law courts, while, as we shall see, no civil dispute involving the smallest sum of money may be tried except by a judge who is a trained lawyer, persons may be tried for criminal offences and fined or imprisoned by judges who may be entirely ignorant of the principles of English justice and completely inexperienced in weighing facts or judging the reliability of witnesses called before them. Special courts of magistrates sit to try juvenile offenders.

All civil cases in which more than a certain sum—usually £200—is involved, or which relate to matters of importance—for example, divorce—are usually tried by a judge of one of the three divisions of the High Court of Justice. The High Court, for reasons of practical convenience, is divided into the King's Bench Division, the Chancery Division, and the Probate, Divorce, and Admiralty Division. Each of the judges of the High Court is attached to one or other of these divisions, but may, and very occasionally does, sit in one of the other divisions when pressure of work makes such an arrangement desirable. In addition to hearing cases in London, the judges of the King's Bench Division also travel on the assizes and hear civil as well as criminal cases. Civil jurisdiction in small cases is usually exercised by the judges of the county court, who are trained lawyers. These courts are in no way connected with the counties in which they sit, but are placed in whatever centres are most convenient.

Courts of Appeal. The courts which we have been considering, both civil and criminal, are all what is called courts 'of first instance,' and it is in most cases possible to appeal from their decisions to some other court. In criminal cases, an appeal on fact or law lies from the assize courts and Old Bailey to the Criminal Appeal Court, and in special cases to the House of Lords, and from Petty Sessions to Quarter Sessions. An appeal on law may be made from Petty Sessions or Quarter Sessions to the King's Bench Division. In civil cases an appeal lies from the High Court to a special Court of Appeal, and thence, with leave of the Court, to the House of Lords. When the House of Lords hears appeals it does so usually through five members, who are either specially appointed as 'Law Lords' or else are peers who have held high judicial office. The other peers take no part in the proceedings. Appeals may also be made from the county court to the Court of Appeal and House of Lords.

LESSON 13

Law of Evidence and Procedure

A BRANCH of the law which to the layman appears unnecessary is that concerned with 'evidence' and 'procedure'; to him it seems designed not at all to aid the court in arriving at a just decision, but rather to hinder it by imposing on it technical and artificial restrictions. The layman in his ordinary life has constantly to make decisions of considerable importance; to enable him to do so he has to weigh evidence and come to conclusions as to facts very much as a judge must do in trying a case. If he cares to visit a court at any time, however, he will find that facts which would have influenced him considerably in arriving at his decision will not be considered by the judge at all, but will be excluded on the ground that they are not 'evidence.' The chief point on which he will differ from the court will be that the court will insist on everything being proved 'at first hand,' whereas he himself has been quite content to rely on second- or even third-hand information, provided that the persons through whom the information has come are known to him to be reliable. Suppose, for example, he wishes to know the market price of the shares of a company in which he is interested, he will telephone to his broker and obtain the information from a clerk, who has himself no personal knowledge of the matter, but who has made inquiries of others who may have seen the price in the official list, or heard it in the market. The information may be of vital importance to the inquirer, and yet he will be perfectly satisfied.

Exclusion of 'Hearsay.' In a court of law, however, information so obtained would not even be listened to, let alone weighed or considered on its merits; the court would not accept even the price quoted in a financial paper, but would require the production of the official Stock Exchange List, a document to which no layman would probably ever refer in the course of his life. This rule of the exclusion of 'hearsay' evidence has been immortalized by Charles Dickens in the case of Bardell v. Pickwick, where Mr. Justice Stareleigh tells Sam Weller, 'You must not tell us what the soldier or any other man said, sir; it's not evidence.'

Readers of that famous case may well have wondered why it was that neither Mrs. Bardell nor Mr. Pickwick was called to give evidence, and why the conversation between them was proved instead by the indistinct 'impressions' of Mr. Winkle on the staircase outside. The reason was that at that time, although the law has since been altered, no person who was a party to an action or interested in the result was allowed to give evidence, for it was assumed that, being interested, he would not tell the truth.

English law has filtered so finely the facts which it allows the court to consider in deciding a case because of the jury system, under which the jury are the judges of fact. A judge, trained and experienced, could no doubt have been trusted to consider the value of 'hearsay' evidence, and give it due weight in his mind, but with a jury, in early days inexperienced, uneducated, and very often unintelligent, the matter was very different. This distinction is preserved, for the court is, when the case is being heard by a jury, given power to refuse to relax the 'hearsay' rule, even in the special cases covered by the act of 1938. Moreover, the law is justified in demanding a higher standard of proof than that which satisfies the layman in his own affairs.

Classes of Evidence. Evidence may be either 'direct' or 'circumstantial.' When a man is charged with murder, the evidence of witnesses who saw him strike the blow would be 'direct' evidence; that he was arrested near the scene of the crime, that his clothes were stained with blood, and that a weapon with which the fatal wound might have been caused was found in his possession would be 'circumstantial.' It is a frequent practice of novelists to write of a wrongful conviction secured by circumstantial evidence; but in practice circumstantial evidence, if the chain of events connecting the prisoner with the crime is strong and complete, can be relied on. Indeed, it may be safer than direct evidence, for it is a fact that the greatest miscarriages of justice have come about through honest but mistaken direct evidence wrongly identifying the prisoner with the person whom the witness saw commit the crime.

Law of Procedure. The law of procedure, dealing as it does with the mechanics of a trial, is of a highly technical character and of but little interest to the layman. It must be obvious to everyone, however, that when a case is to be tried involving many facts as to which there is a controversy between the parties, it would be impossible for a judge to try the case simply by calling both parties before him and asking them to tell their stories. It is necessary first that the 'issues' should be determined; namely, that each party should state in writing the facts on which he relies in support of his case, and should further state whether he admits or denies each of the facts alleged by his opponent. These statements of facts are called the 'pleadings,' and the judge on reading them will quickly and easily discover what is in dispute between the parties.

All cases in English courts, with a few exceptions, must be heard in public. This rule has been of great importance in the development of the law, for it ensures that the enormous force of public opinion is brought to bear on the proceedings, and 'that justice should not only be done but should also *appear* to be done.' The litigant who has lost his case must leave the court confident, it may be, that the judge has been wrong and the jury stupid, but also conceding that the facts in his favour have been fully heard and considered by an impartial court.

Another procedural rule of great importance is that the burden of proof is in almost every case on the plaintiff in civil cases and on the prosecution in criminal trials. It is for the prosecution to prove that the prisoner is guilty, not for the prisoner to establish his innocence. This is of great practical importance, for should the prosecution fail in this task the accused may, without taking the risk of giving evidence and exposing himself to the possible dangers of cross-examination, submit that there is 'no case' to answer and demand an acquittal.

LESSON 14

The Legal Profession

While any litigant is entitled, if he pleases, to conduct his own case before any court in this country——and some frequently do so—the advantages to be obtained from the employment of trained persons to present his case for him are obvious. It is not only that the presentment of the facts of a case to the best advantage is a matter of great difficulty, demanding considerable natural ability as well as experience, but also the intricacies of the rules of evidence and procedure will almost inevitably lead to many blunders by the litigant in person. Nevertheless, many private persons prefer to conduct their own cases, and some of them—for example, the late Horatio Bottomley—have done so with outstanding success, even when they were opposed by the most skilful members of the professional bar.

Monopolistic Lawyers. The profession of law constitutes a monopoly even more absolute than that of medicine, for, while there is nothing to prevent any person without any qualifications from acting as a doctor, and from receiving fees for his work, so long as he does not describe himself as a qualified practitioner, no unqualified person may take any reward for work which should properly be done by a member of the legal profession. Further, so far as one branch of the work of a legal practitioner is concerned—namely, appearance in court—no person is entitled to represent a litigant unless he is (in the higher courts) a barrister or (in the lower courts) a solicitor. This rule frequently leads to difficulties in cases where a limited company is a party, for, technically, the company, being a legal person distinct from its directors and shareholders, cannot appear in person, and cannot be properly represented by a manager or other representative. In cases involving large amounts of money this difficulty does not arise, for a barrister and solicitor will in any event be employed; but in small matters, where the claim is not disputed, strict adherence to the rule may cause great inconvenience.

Concerning Barristers. The legal profession in England has two branches—barristers and solicitors. This division, although not unknown abroad, is there the exception rather than the rule, and in this country is founded on historical reasons. A barrister must not be approached direct by a litigant, but can only be 'instructed' through the mediation of a solicitor. It is frequently suggested that this duplication makes litigation costly and is not justifiable. In defence of the system it is contended that it enables the litigant to obtain more highly skilled advice and assistance than any other system, since it encourages specialization among barristers; and a solicitor has a knowledge of the specialists in each branch of the law, which the litigant himself cannot have, and can thus put his client in touch with the barrister best qualified to assist him in his case.

A barrister is characterized primarily by the fact that he presents his client's case in court to a judge or jury; a solicitor's normal duty is to make the case ready for presentation, usually under the advice of the barrister. It is probable that originally the barrister was merely some person who was in court when the litigant's case came on for hearing, and who then volunteered to assist him. Gradually a class of persons came to be recognized as competent to be 'of counsel' with litigants, and to be called 'counsel.' Today the authority entitled to appoint barristers by 'calling to the bar' is not the court itself, but one of the four Inns of Court—Lincoln's Inn, the Middle and Inner Temples, and Gray's Inn. These are societies of barristers ruled each by their 'benchers,' who have very autocratic powers and are not controlled by the societies or, indeed, by any other body. In theory, at least, they have an almost absolute discretion as to the persons whom they will call to the bar; but in practice they will as a rule call any person, whether a British subject or a foreigner, who is of good character and possesses certain qualifications.

These qualifications are twofold. The candidate must pass certain examinations in law, and must also 'keep' twelve terms spread over three years by dining in the Hall of his Inn on six occasions (or in the case of a member of certain universities, three occasions) in each term. The eating of these dinners is probably a survival from a time when the candidate was required not only to dine, but also to reside within the precincts of his Inn for a certain number of terms. No such residence is now possible, for all accommodation at the Inns is used by practising barristers as their business premises, and the Inns have no 'corporate' life such as is found at a university.

When the candidate has complied with these regulations, he is formally called to the bar by the benchers on Call Night. After he has been called, a barrister is subject to his benchers so far as professional conduct is concerned, and if he offends he may be 'disbarred.' There is also a class of barristers known as 'King's Counsel.' These are appointed by the Lord Chancellor for the Crown, from among the senior and successful barristers. They confine themselves for the most part to the actual conduct of cases in court, where they occupy a front row 'within the bar' of the court, distinct from the ordinary 'outer' barristers, and they cannot appear unless an ordinary barrister is also briefed. Their cases are usually fewer, but their fees larger, than those of an ordinary barrister.

Concerning Solicitors. Solicitors undergo a course of training very similar to that of a barrister. They must be apprenticed to a practising solicitor for a period varying from three to five years, and must also pass certain examinations in law. The Law Society controls solicitors, admitting them to practice and removing them from the roll if they are guilty of professional misconduct. The solicitor may appear in certain inferior courts on behalf of his client, and will normally do any conveyancing work—i.e. the preparation of deeds—for his clients without assistance from the bar. Further, he will advise his client on law, and will not take the 'opinion' of a barrister unless the case is of unusual difficulty. It is only when litigation commences that it is customary to introduce the client to some barrister. A solicitor is entitled to sue a client for his fees, whereas a barrister is not, and must rely upon the honour of the solicitor who instructs him, and whose duty it is to see that the fees are paid. By way of compensation, a barrister cannot be sued for negligence, but a solicitor is liable if he fails to act with proper care.

LESSON 15

International Law and Its Enforcement

INTERNATIONAL law consists of the rules acknowledged by civilized states to be binding on them in their mutual relations. This definition may not appear very satisfactory in view of our earlier definition of laws as 'rules of conduct enforced by the State.' We then saw that one of the most important features of laws as distinct from rules of conduct which were not laws was that the former were enforced by some definite sanction, while the latter were enforced only indirectly by some sanction such as public opinion. It is proper to say that an element of 'compulsoriness' is essential to the very idea of law. Is it then correct to refer to the rules of conduct between nations as 'laws' or should we not call them 'international morality'?

The answer must be that these international rules have not yet reached the stage of full development under which any nation would be judged by an international court and punished by some international authority. The events of recent years have proved once more that there is more than a little truth in the allegation that some countries will keep their treaty obligations only so long as may suit their own interests. The breach may offend international opinion and lead to war, but since, unfortunately, right does not always triumph, in the war the breaker of treaties may be victorious, so that the breach of international law may not only go unpunished, but may even be rewarded.

Early International Law. Nations seem to have recognized, from a very early time in history, the necessity for having some form of rules governing them in their relations with other nations. These rules were not called into being by any humane instincts, nor by any desire to better international relationships, but merely dealt with matters in which a certain reciprocity of treatment was necessary if international relations were to exist at all. The best example of early international law is to be found in the laws relating to heralds and safe-conduct. The sanctity attaching to the office of herald is well illustrated in the Bible, when the people of Ammon, in sending back David's ambassadors with one side of their beards shaved off, were thought to have committed an international atrocity (2 Samuel, 10). The breach of a safe-conduct was likewise regarded as a very serious reflection on the honour of a nation. The reason for these rules is obvious—your herald is in my power today, but my herald may be in your power tomorrow, and a great saving in heralds will be effected if we each refrain from the somewhat easy game of cutting their throats; otherwise no one will come forward to act as herald between us.

International Arbitration. Two international authorities have been set up with the object of enforcing international law. The first, the Permanent Court of Arbitration at The Hague, came out of the first Peace Conference summoned in 1899 through the influence of the Emperor Nicholas II of Russia. But the decisions of the Court could, in any case, be binding only on those nations which ratified the convention, and not even all those attending the conference did so. Several of the powers, however, including Great Britain, appointed members of the Permanent Court, which tried its first case, that of the Pious Fund of the Californias, between the United States and Mexico, in 1902. It was instrumental in settling a number of other international disputes, notably one between Great Britain and the United States over the Newfoundland fisheries (1910). (*See* Modern History, Vol. VI, p. 85.) Germany, Japan, France, Russia, and Italy were other powers which submitted to the court's arbitration. The defect of this system was, of course, that if the parties, even after acceptance of the convention, did not submit their disputes to arbitration, no authority existed with power to compel them to do so.

Nevertheless, the arbitrations of the Hague Court did considerable good. Most important of all, perhaps, they raised the status of arbitration and prepared the world for the League of Nations set up by the Treaty of Versailles (1919). The Covenant of the League included a great number of provisions for the peaceful settlement of disputes between states which were members of the League, and made some attempt to ensure that nations should not only submit their disputes, but should also abide by the decision given.

Every member of the League undertook to submit any dispute to inquiry by the Council of the League, or to arbitration, or to the decision of the Permanent Court of International Justice at The Hague created by the League in 1920. Article 16 contained the very important provision that if any member of the League failed to submit disputes or to abide by the decision given, but resorted to war, it was to be considered as having committed an act of war against all the other members of the League, who were then pledged to bring pressure to bear on the offender by severing trade and financial relations, and to contribute military and naval forces necessary to protect the Covenant of the League.

What led to the failure of the League system is a matter of dispute. In some cases nations voluntarily severed their connexion with the League, as they were legally entitled to do; in others, some members of the League were unwilling to apply the sanctions against other members who infringed the provisions of the Covenant, sometimes through friendship with those members, sometimes through fear. Whatever were the reasons, the system failed, and one of the greatest hopes of the future is that the nations of the San Francisco conference of 1945 may prove to have succeeded in establishing a means for the enforcement of international law.

Rules for War and Peace. International law lays down rules intended to be observed by nations during both peace and war. The rules of war attempt to limit its brutality and cruelty—e.g. a state abiding by them must not kill prisoners, and must not attack hospitals—and also regulate the relationship between neutrals and the belligerents, stating what acts neutrals are entitled to do to assist one belligerent without interference from the other—e.g. supply of food—and the important questions of blockade and contraband. This country in the First Great War in carrying out the blockade of Germany, which had such an effect on the issue of the war, claimed wide powers of interference with neutral ships, not only when carrying cargoes to Germany, but also when bound for some neutral country, if there were any reason to suspect that the cargo was ultimately intended for Germany. Particularly did these difficulties arise while the United States remained neutral. During the Second Great War there were so few neutral countries that this aspect was less prominent.

In time of peace the rules of international law deal with less far-reaching matters. They concern such things as the extradition for trial of persons charged with crimes in another state; the rights of sovereignty enjoyed by independent states; and the privileges and immunities of ambassadors and other diplomatic representatives.

LESSON 16

Roman Law and the Law of England

The English Common Law prevails in Australia, New Zealand, the United States of America, and the greater part of Canada. Yet it cannot compare in the extent of its sway with the system built up by the Roman empire over 1,500 years ago, which, like the other products of that great empire, has left in the world a mark so deep that it seems it can never be effaced. Modified in some parts by local customs, it prevailed in Italy until the rise of Fascism, in Germany until the Nazi revolution, in Greece, France, Belgium, and Holland until they were overrun by the Nazis in 1940 and 1941, and was the foundation of law in the rest of Continental Europe, and in all those parts of the world outside Europe which were at one time colonies of France or Spain, such as the republics of Latin America, Louisiana and the Province of Quebec. In Scotland the law has also been built on Roman foundations, but the land law and, more recently, commercial law have followed more closely the English model for reasons of convenience. It will be seen, therefore, that the English Common Law and Roman Law between them cover nearly the whole of the world, and no course of legal studies would be complete which did not contain some consideration of their growth and the methods by which they spread.

The Law of Ancient Rome. Roman Law, as it existed before the Second Great War, was directly descended from the law of ancient Rome. The law in the first place spread outwards from Rome by conquest. The Romans endeavoured to assimilate to themselves the peoples they conquered. Rome's early conquests were directed to the absorption of the rest of the Italian peninsula, and at this time the principles of Roman Law, as we now know them, were not yet in existence, nor were they required, for the neighbouring cities conquered were already provided with laws or customs of their own. Soon, however, the area of Roman influence spread, until by the first century A.D. all Europe (with the exception of Scandinavia and the eastern parts of Germany), North Africa and Asia Minor were within the empire. These vast provinces could be divided into two classes. In some, such as the Greek cities, there had been for centuries an advanced civilization older than that of Rome herself, and there existed systems of law requiring little addition from their conqueror. Others, such as Gaul, Spain, and Britain, were in a much lower state of civilization, and such laws as they possessed were mere tribal customs, totally unsuited to the needs of the new and wealthy communities which sprang up under the Roman influence. The second class was naturally more likely to assimilate the laws of Rome than the first.

The administration of the law in each province was in the hands of the governor. It was always the policy of Rome to extend as far as possible the benefits of Roman citizenship, and so many of the inhabitants of the provinces received the citizenship although they were not of Italian birth. It will be recalled that St. Paul was a Roman citizen—' born free '—because that honour had been granted to all the inhabitants of Tarsus, his native city. Now, one of the rights of a Roman citizen was to be ruled according to Roman Law, and to have his cases heard by the governor of the province; and so we find at a very early stage in the development of a province that the most privileged inhabitants are governed not by their local laws but by the law of Rome, and, since the citizenship was highly valued, so the Roman system was held in higher esteem than the local laws. The governors were men who had been in close touch with the centre of the empire, and each was accustomed to prepare at the beginning of his term of office an ' edict ' setting out the laws according to which he proposed to govern. This list would be for the most part a reproduction of his predecessor's, but the power of alteration prevented the law from becoming formal or out of date, and enabled it to keep abreast of changes at Rome itself.

It was thus an excellent system for the speedy dissemination of general principles of law throughout the world, and when Roman Law threw off the formalism which had at first restricted it, and developed into a liberal and elastic system founded on general principles of justice and suited to the needs of commerce, its advantages were immediately recognized. When, in the third century A.D., the grant of full citizenship was made to all inhabitants of the empire, the one law became applicable to all inhabitants in every province, whatever their stage of civilization; and it is one of the most striking tributes to Roman Law that it was capable of meeting these most varied needs.

Thus, before the breakdown of the empire in the 5th century and the coming of the Dark Ages, nearly every country in Europe had enjoyed for a period of time extending to centuries the benefits of Roman Law, and the principles of that law survived, often merely as local customs, until the revival of learning at the Renaissance, fostered by the Church, which in her Canon Law had preserved a great part of the principles of Roman Law as laid down by Justinian (*see* Lesson 28 *in* Ancient and Medieval History, Vol. II, page 138) in his famous code and by the great jurists of the Roman world.

English Law in the Wider World. The spread of English Law has followed a somewhat different path. First, the time occupied has been much shorter, for it has been confined to the last three centuries. Secondly, the spread has been due, except in India, to colonization and not to conquest. Further, the communities to which the law has been extended have been themselves of British stock, and have taken the Common Law with them and not adopted it in substitution for any local laws of their own. These facts are of interest when we endeavour to forecast the future and to ask whether either of the two great systems will ever prevail to the exclusion of the other and, if so, which will be successful. It is probable that neither will ever oust the other, but that, with the weakening of international barriers and the extension of international commercial intercourse, the two will to some extent be merged and produce one system of law with worldwide application. This is more likely to be the case in that part of the law that is concerned with commerce than in the law of crime or of marriage and family relationship, for the more the element of human emotion, as distinct from economic considerations, enters into the law, the more the law differs from state to state, and the greater is the opposition to change.

LESSON 17

Law and Religion Through the Ages

On many points religion and law differ fundamentally, and the reader may wonder why they should together form the subject of a Lesson. Law, as we have seen, is concerned with man's conduct and not with his thoughts; religion, though it may require certain devotional acts and a certain standard of conduct, is yet essentially and primarily a matter of the spirit. Thus the commandments of Moses forbid a man to covet what is his neighbour's. Law proper would not interfere with a man so long as he confined himself to the purely mental act of coveting. Again, law necessarily amounts to a restriction on individual human liberty by the State, and can be justified only by the assumption that individuals would abuse their liberty to the injury of others without the law's control. Thus law is made necessary by the imperfections of mankind, for Man, in a perfect state, living according to the will of God, would not require law.

Religion's Part in Primitive Law. On the other hand, there are in law and religion certain points of similarity. First, each endeavours, as part of its task, to enforce the rules of morality. It would be a mistake to imagine that this is the chief object of either. The law, as we have seen, will not punish or forbid acts merely because they are morally wrong; thus adultery may not be a crime. Religion, though more closely concerned with morality, would not contend that the enforcement of moral rules was its only object. Nevertheless, so far as law and religion are both concerned with the enforcement of moral rules, they may be said to have a fundamental component in common.

It is when we turn from the present to times in the more distant past that we find law and religion so closely connected as to be distinguished only with difficulty. In primitive society the priest is also the lawyer, and the only laws known are those enforced by a religious sanction. We have seen that the early codes are usually regarded as of divine origin, and that many of their laws are both religious and secular. Thus a rule which in its original was founded on considerations of a sanitary nature, equivalent to our modern law of public health, in later history develops into a regulation of merely ceremonial purity—for example, ceremonial ablutions—the practical consideration which first gave rise to it being forgotten, and the rule remaining merely as enjoining some religious observance.

Again, the punishment of the breach of a 'law' in the early state is frequently a fine which is considered not as a penalty to punish the offender, but as an atonement for sin to propitiate the Deity whose law has been broken. We have also noticed the religious element in the development of the law of contract. In Rome the parties desiring to contract appear before the priest, and one party, using certain set words, *vows* to the Deity that he will carry out his side of the bargain. In medieval England the courts of the Church enforced promises made by one person to another (which the ordinary courts would not recognize) on the ground that they were correcting a sin, namely, a breach of plighted faith.

One very interesting survival of this attitude is to be found in our modern religious marriage ceremony. As we have seen in Lesson 8 (page 447), marriage is a contract between the two parties, but when the ceremony is a religious one it is also something much more, for the parties not only contract with one another, but each also 'plights troth' to the other—entering into a solemn vow at the altar to fulfil the marriage obligations. Here the vow is not made directly to the Deity, but is made to the other party to the contract, and the Deity is, so to speak 'called to witness.' Law and religion are nowhere so closely allied as in the obligations arising from marriage and the family. The laws that regulate marriage, the relations of parents to children, and the devolution of property were often precepts of religion before they became rules of law.

Another use of the vow is to be seen in the realm of early international law, when kings would meet and vow upon some sacred relic to observe the terms of a treaty or to grant a safe-conduct to some enemy through their country. This use of the sanction of religion to enforce the law was a device of great practical value. Today obedience to the law is secured to a great extent by having a large number of policemen ready to detect any infringement. In the Middle Ages there were no policemen, but God was utilized as a universal police force, if one may use the expression. He was present everywhere, and every prospective wrongdoer knew and believed that whether or not the *law* ever discovered his crime, it would be known to, and punished by, the Almighty.

So far we have considered cases in which the law has been assisted by religion. Very frequently, however, we see the reverse process operating, when the State tries to compel the observance of some particular religion by means of the law. Religious tolerance is of very recent growth in this country and elsewhere, and it might be said with accuracy that until the 19th century either certain religious beliefs and observances were enjoined in every country or else those who failed to accept the faith of the majority were subject to certain disabilities. So far as Catholics are concerned, most of their disabilities were removed by the Catholic Emancipation Act of 1829, and several later relieving acts. It is probably still today the case that a Catholic could not accept the office of Lord Chancellor or that of High Commissioner to the General Assembly of the Church of Scotland, because he would be unable, by reason of his religion, to make the declaration against transubstantiation which, it is generally held, would be required.

Before the Reformation the State did not as a rule interfere to compel the acceptance of any particular religion. Religious feeling —in the sense of conscious antagonism between different creeds—was unknown, for the simple but excellent reason that in Christendom there was but one religion. Divisions in the Church were, it is true, plentiful and sharp, but the State was not concerned with such differences. Accordingly, the State usually left it to the Church to deal with heretics, which it was fully competent to do. It is only after the Reformation that we find the State taking any direct steps to dictate to its subjects the religion to which they should belong, and the burnings and martyrdoms which followed are too well known to need more than mention here.

Penalties on Religion. In the 16th and 17th centuries the State's support of religion took another form—less sanguinary, although perhaps more effective. By a series of acts, fines and penalties were imposed upon all who professed or observed the Catholic religion, and on members of the Nonconformist bodies. For example, by an Act of Elizabeth Catholics who refused to observe the State religion were forbidden to move more than five miles from their usual place of abode without a special licence. Catholics and all other Dissenters were further debarred from holding most offices by the well-known Test Act in the reign of Charles II. It is impossible to set down here in detail the laws directed against Catholics and other Dissenters, but so severe were they that, if they had been rigorously enforced, it would have been almost impossible for any nonconformers to the Anglican Establishment to live in England. In practice, however, the laws were not strictly enforced, the Nonconformists in particular being accorded a considerable measure of relief by the Toleration Act of 1689. It was left to the 19th century to repeal the penal laws against non-Anglicans and to establish here full religious tolerance. After Catholics and Nonconformists had secured the removal of their disabilities, there was yet to come a struggle to remove disabilities from Jews and atheists.

We may conclude by mentioning one famous instance in which the law has endeavoured to add to its strength by holding itself out to be a rule of God as well as a law of the State. James I and other Stuarts seized upon and elaborated the idea of the divine right of Kings, the theory that the King was by God appointed and that resistance to him was not only treason but a sin. The attempt to support the King's title with a religious sanction did not succeed, and the final failure was marked by the Act of Settlement, by reason of which the sovereign has since held the throne under a Parliamentary title.

LESSON 18

Should Our Law be Codified?

THERE has been for a great many years a strong movement in this country in favour of a codification of the law—that is, for a statement in simple language by Act of Parliament of all the legal rules which are at present to be found only by the exhaustive examination of many statutes and of decided cases in the law reports. Jeremy Bentham over a hundred years ago was one of the most active advocates of this reform, but it cannot be said that much has been done to implement his ideas.

We have already seen that a great part of the law of England is not to be found in any Act of Parliament, but is regarded as the common law, declared by the judges in decided cases. It might perhaps be thought that 'judge-made' law of this kind is as good as any other, and that the law reports could be regarded as supplemental to the statutes, and as forming with them a complete code. This, however, is very far from being the case. A statute—and a code—purports to state the law word for word, and must be read literally; a decided case does something very different. It does not provide a general statement of law, which can be applied to all cases, but merely illustrates and declares a principle of law applicable strictly only to the particular facts of the case. Indeed, it is never possible to say more than that a certain case provides an illustration of the working of a legal principle, which even if it is stated in wide and comprehensive terms, is to be read only with reference to the facts of the case.

If later a case arises, the question whether it is covered by the principle declared in the former case will depend not only on reading the grounds of the judgement of that case, but on a detailed consideration of the facts, and also of the facts of any other cases which are relevant.

It is perhaps impossible to make the law so simple that it may be easily understood by a layman without legal training, but it is surely not asking too much of the legislature that the trained lawyer may be enabled to find the law on any subject clearly stated in some authoritative document instead of being required to devote time to research, and then deduce the law from a series of cases which are frequently contradictory.

Judge-made Law. The real and most serious objection to our system of judge-made law is that the litigant is required against his will to pay for the very expensive process of enabling the courts to make the law. That this is a serious defect will be at once appreciated when it is realized that to carry a case from the judge of first instance and thence to the Court of Appeal and the House of Lords may cost the unfortunate litigant as much as £10,000. He may have been perfectly justified in commencing the litigation, as he was advised that he was right in law; he may be encouraged by a victory in the court of first instance and Court of Appeal; and when, finally, he is taken to the House of Lords he may be defeated, the decisions of the courts below overruled, and all the costs of the hearings in all courts piled upon the litigant. It should be noted that frequently the litigant has no choice about proceeding to the Appeal Courts, for he is taken there by his unsuccessful opponent. It can be of little consolation to such a litigant to know that he has added his name to a 'leading case,' and he cannot be blamed if he upholds the view that the legislature should have foreseen his case, and has failed to do its job.

It is not too much to say that certainty and clarity should be two of the law's essential attributes, and it is just these two that are lacking in our system of judge-made law. Every leading case is evidence that the law has failed. Anyone who cares to visit one of the law courts in the Strand when a case is being tried may see each counsel quoting, it may be, a dozen or more reports of decided cases and referring to perhaps as many statutes. Among these various authorities the judge has to pick his way, first deciding what each means, and then giving due weight to each. For this purpose he must have regard to the date when the case was decided. If it is very ancient—and cases one hundred years old are frequently quoted—he may attach less weight to it because the manners and customs of business may have changed in the meantime.

If it is a decision of the Court of Appeal, it is of higher authority than decisions of lower courts, but only in so far as it deals with the same set of facts as the decisions of the lower courts, and it may be that the judge will decide that the one does not overrule the others but establishes a different legal principle. Finally, he is entitled to attach some importance to the reputation of the actual judge whose decision he is considering. When the case is at last decided, it may be that some vital point of English law is established, but, in one way, the position is only made worse, for while the case decides the point in issue, it also adds one more authority to the long list of cases to be referred to when a similar point arises in the future.

The seriousness of this will be recognized when it is realized that each year some thousand cases are added to the reports—and a case is not reported unless the reporter considers that it either declares some new legal principle or extends or modifies an old one. Would it not be better, say the advocates of codification, to abolish the doctrine of precedents, sweep away the law reports, and state the law simply and clearly in a codifying statute after the model of continental countries? Swift gave expression to the same thought when he made Gulliver report that no law in Brobdingnag might contain more than 22 words, and that to write a comment on the law was a criminal offence.

Although the defects of our present system are only too apparent, it cannot be said that attempts at a solution of the problem have been attended with great success in this country. It is unfortunately anything but true to say that when Parliament has passed a statute, no doubt or litigation can arise as to its meaning. The most notorious example of this is the Workmen's Compensation Act of 1906, which has been a veritable gold mine for the legal profession, and even now, nearly forty years after it first became law, provides sufficient material each year to fill a volume of leading cases of several hundred pages. Yet the language of the statute is at first sight exemplary in its simplicity. In many instances, however, Parliament seems quite incapable of expressing itself in intelligible English, and frequently it is obvious that statutes have been drafted without a proper regard to pre-existing and contradictory enactments.

Successful Codification. In some cases, however, codifying statutes have been eminently successful. The Bills of Exchange Act, 1882, and the Sale of Goods Act, 1893, have both been of great assistance to business men in clarifying the law on these topics, as the reduction in the quantity of litigation on these subjects bears witness. These statutes, however, do not represent part of a plan for codifying the whole law, but are merely isolated ventures. It may be that the codification of certain selected topics is the furthest that we shall go in England, for the law is so vast that any attempt to compress it within the limits of one document would be too gigantic an enterprise to be practicable.

Two factors have been operating of recent years to add vigour to this process of codification. The first is the preparation unofficially of digests endeavouring to set out the law in the form of a code. The other has been called out by the necessities of the Empire: many codes have been prepared for use in the dominions, colonies, and dependencies. In Canada, for instance, this was due to an attempt to introduce one uniform law for the whole federation, where previously the law differed from province to province: in Kenya, on the other hand, it was necessary to introduce new law for a new settlement. It is to be hoped that the example may be followed in this country, and that the litigant may be saved the heavy burden now imposed upon him of paying for establishing points of law for the benefit of the legal profession and of posterity.

LESSON 19

Law Reform

THE English legal system has many features of the highest value, but, as we have seen, it is not perfect. Times and manners change, and it is vital that the machinery by which the law is administered should change with them. Moreover, change is difficult, for there is about our legal system a tradition and dignity which make criticism seem almost an impertinence.

The two main requirements of any legal system are that the machinery by which the rules of law are applied should operate fairly and be available to everyone. Let us consider how far the English legal system fulfils them.

No one with any knowledge of our courts could ever question their impartiality. Even an unsuccessful litigant will usually concede that he has had a fair trial and been fairly treated, and where one meets the exceptional case it will be found that his charge of unfairness is either entirely unjustified or should be directed not against the court but against the rules of evidence or procedure which the court is bound to follow. Anyone who cares to spend an hour or so in his local magistrate's court will soon come across an example of rules which give this mistaken impression of unfairness.

A Fair Hearing. After the case of the prosecution has been outlined, one or more witnesses will give evidence in support of it. As the evidence of each comes to an end the magistrate will turn to the accused and say, 'Do you want to ask the witness any questions?' thereby giving him the opportunity of cross-examining the witness—a process always difficult, though of course an everyday matter for the professional lawyer. The accused has, however, usually not the least idea what he is expected to do, and the less frequent have been his appearances in court, the greater will be his ignorance. He will be anxious to give his version of the story at the earliest possible moment and will naturally assume that this invitation to 'ask questions' gives him his opportunity. Before he can say a dozen words, however, he will be stopped by the court—sharply, or not, it makes little difference—and told he must ask questions now, not make a statement, and that later he will be given an opportunity to make his statement. This procedure, which legally is strictly correct, will be repeated at the end of the evidence of each of the prosecution's witnesses, and the accused will on each occasion probably receive the same rebuff, with the result that when finally he is given his chance to tell his story he will long since have come to the conclusion that no one will listen to him whatever he says, and so he says nothing. In cases between husband and wife the court is now required to cross-examine witnesses on behalf of the parties and this procedure might well be extended.

High Cost of Litigation. 'The law courts are open to all—like the Ritz Hotel,' is a saying attributed to Mr. Justice Darling, and it has lost nothing of its sting.

Where a man able to pay simply refuses to do so, the law does, it is true, provide the creditor with a comparatively cheap method of enforcing his claim. Where, however, there is a genuine dispute as to the claim, the costs will be out of all proportion to the amount at stake, except in the rare cases where large companies litigate over matters involving tens of thousands of pounds.

It is true that the losing party is usually ordered to pay the winner's costs, but this safeguard is illusory. In the first place, one of the facts it is most difficult to bring home to the ordinary layman is that to have an order requiring some person to pay one money is a very different thing from having the money in one's pocket. The loser may be ordered to pay the costs, but he may be penniless. He may have already spent all he had in the litigation, and the winner must of course pay his own costs whether or not he can recover the money from the loser. Again, the winner is not entitled to recover from the loser the full sum the proceedings have cost him. His costs are considered in detail by a taxing master who disallows any items he does not consider absolutely necessary—for example, inquiries that were quite properly made in the hope of obtaining evidence, but which in the end produced no result. The fact that these items are 'disallowed' by the taxing master does not mean that the winner must not pay them to his own solicitor. Thus, in the end, the winner will nearly always have to pay part of his costs out of his own pocket.

Even if the winner recovered every penny, however, this would not justify the high cost of litigation, for it is surely unfair that a man of moderate means should be able to take or defend proceedings to enforce what he is advised are his legal rights only at the risk of financial ruin should the court decide against him.

Legal Fees. It is difficult to say what is the cause of these high costs. Solicitors do not as a rule grow rich out of litigation; barristers' fees are, it is true, high, and the fact that in all proceedings in the High Court it is necessary to employ both solicitor and barrister (and sometimes two barristers) is in itself an obvious addition to the costs. This is, of course, an argument for the amalgamation of the two professions. The litigant is himself, however, largely to blame for the 'fancy' fees sometimes paid to barristers. In litigation, as in illness, he wants the best that he can afford and insists on briefing the better-known and more expensive barrister.

There are, of course, cases which have been won only by the brilliance of the barrister conducting them, and experience is an asset always worth paying for, but nevertheless nine times out of ten it would be possible to find a dozen experienced barristers any one of whom would conduct the case quite as well as the more fashionable and therefore more expensive barrister.

Other causes of our high legal costs which can only be mentioned here are the rules of evidence which require the most elaborate proof of every fact (*see* Lesson 13) and our extensive system of appeals which may involve a litigant in three (or even more) hearings of his case (*see* Lesson 12). It should be realized also that it is the litigant who pays for the mistakes of the judges in the very difficult task of applying our legal rules; and a litigant who has won in one court but lost on appeal will have to pay not only the costs in the appeal court but also the costs in the lower court in which he was at first successful.

Poor Person's Procedure. While litigation is thus so hazardous for the man of moderate means as to be almost impossible, the position is of course different for the rich company and also, somewhat curiously, for the very poor individual. A man without assets has little to fear from being ordered to pay his opponent's costs if he loses his case, but his difficulty will be, of course, how is he to obtain the money to fight in the first place? In civil proceedings, a person whose income does not exceed £2 a week (£4 in special cases) and who is not worth more than £50 (£100 in special cases) may apply for a certificate entitling him to take or defend proceedings as a poor person. If the certificate is granted he will pay no court fees, and a solicitor and barrister will conduct his case without charge. All he will have to pay will be certain out-of-pocket expenses in respect of which he pays a deposit of from £3 to £5.

One obvious objection to this system is that the limit of means of persons who come within it is too low. Another and more serious defect is that the system applies only to the High Court and not to the County Court, which is primarily the poor man's court, dealing as it does with nearly all disputes not over £100 and many up to £200, and also with most cases between landlord and tenant.

In addition to this official Poor Person's Procedure, there are some excellent unofficial 'Poor Man's Lawyers' operating in many parts of the country where barristers and solicitors voluntarily give free advice; but there are few of them and as a rule they have to limit themselves to giving advice: if the poor person is told he has a good case, he must usually himself find —and pay—a solicitor who will conduct it for him. Free legal aid is still more necessary in criminal cases, when a man's life or liberty may be at stake. In such cases the costs are not as a rule so high as in civil matters, but they are undoubtedly sufficiently high to make it quite impossible for most accused persons to employ a solicitor or barrister.

Since 1930 machinery has existed whereby the court can in serious cases order a man to be defended out of public funds, if he has not sufficient means to pay for his own defence. The criticism usually directed against this scheme is that courts do not exercise this power as frequently as they should do, possibly because many accused persons are quite unaware of their right to ask for legal aid.

The greatest obstacle to reform of our legal system is lack of public interest. As was stated in the first of these Lessons, the average man for the greater part of his existence never gives our legal system a moment's thought. The public's conscience is today very sensitive to any inadequacies in our social services which make it possible for a man to be deprived, because of poverty, of medical attention when he is ill or of the means of livelihood when he is old; but it is not generally realized that his poverty may cause him almost as great hardship by depriving him of recourse to our courts.

LESSON ONE

Constitutional Law and Its Sources

CONSTITUTIONAL law may be very shortly defined as the law relating to the government of a state, the law defining the relationship between those who govern and those who are governed, provided that it is remembered that those who govern are usually also subject to the law. In the government of any state three functions will be seen in operation. There must be some persons to say what acts may be done, some persons who do acts purporting to be justified by the permission given, and some persons who decide whether acts done have, in fact, been justified by the permission. These three functions are performed by the legislature, the executive, and the judiciary.

There is no reason why all these functions should not be performed by one person, and in a state governed by an absolute monarch they would be so performed, as witness the remark of Louis XIV, '*l'Etat, c'est moi,*' which was not mere vainglory but correctly stated a constitutional fact. In democracies, however, particularly in the United States, these functions tend to be divided among several bodies (with considerable overlapping), and the rules by which they are divided in any state make up an important part of the constitutional law of that state. An attempt to discover where these rules are to be found will lead at once to a very important discovery so far as this country is concerned. An American, when he talks of the constitution of his country, has no difficulty in knowing to what he is referring. He can buy a copy of a document entitled 'The Constitution of the United States, established and ordained by the people of the United States,' and if any question arises as to whether any act is or is not constitutional—i.e. whether any body in the state has exceeded the powers reposed in it under the division referred to—the answer will be found by a consideration of the terms of that document and its amendments (*see* Politics, Vol. VI., Lesson 28).

The British Constitution. An Englishman, however, is in a very different position. There is no document, or even collection of documents, containing the authoritative statement of the whole of the British constitution. A witty Frenchman once expressed this peculiarity by saying of our constitution, '*elle n'existe point!*' The truth is that the constitutional rules do exist, but since as a whole they are not the result of any preconceived plan, they must not be sought in any one authoritative document, but deduced from many sources, a task which, as we have already seen, is quite beyond the scope of the layman and is, indeed, not without its difficulties even for the professional lawyer.

These sources are of two kinds: the laws of the constitution proper and the conventions of the constitution. The first includes both written statute law and also unwritten common law to be derived from the decisions of judges. Instances of statute law are Magna Carta, 1215; the Petition of Right, 1628; the Act of Settlement, 1701, which established the house of Hanover as successors to the throne of England; and the Declaration of Abdication Act, 1936, by which King Edward VIII abdicated and the Crown passed to King George VI. An instance of common law is to be found in the maxim, 'the king can do no wrong,' which has been declared by the courts to mean that the Crown is not responsible for any civil wrongs done by its servants.

Conventions of the Constitution. The laws of the constitution are part of the ordinary law; the conventions of the constitution are not in reality laws at all, for they are not enforceable by the courts. They are the habits and practices of political life, and a breach of them might have political, but could not have legal, consequences. There is no law, either in the statute book or in any reported case, which makes it a legal offence for a government that does not enjoy the support of a majority in the House of Commons to refuse to resign, or which compels Parliament to meet every year. These are conventions, but at the present time they are observed as carefully as though they were laws, although their force rests merely on convenience and custom.

The conventions of the constitution may change through alterations in political thought. Thus, it may be said today that it is a convention of the constitution that the king should not veto any bill which has been passed by both Houses of Parliament; yet 200 years ago no such convention existed, and the change has been brought about without the passing of any law.

It should be noted that the distinction which has been drawn between the English and American constitutions is not that between a constitution that is unwritten and one that is written. A constitution is written so far as its rules are to be found in some authoritative document or documents such as a statute, and unwritten so far as its rules are to be deduced from general principles established by decided cases or practice. Thus the English constitution is written so far as its laws are to be found in statutes. Further, even in countries with constitutions declared in one document, conventions grow up as they do in Britain, and with, in practice, the force of law.

Thus the intention of the framers of the American constitution was that the president should be elected by a body of electors, themselves elected by the people. The electors were intended to use their own discretion in their voting. Now, however, the electors are themselves elected on a ticket system, and a vote for any elector represents a vote for a particular presidential candidate whom he is pledged to support. Yet this change has been brought about without any amendment of the American constitution.

Now although such conventions of the constitution are of great interest and practical importance, they are not enforceable by the courts, and this fact prevents them from belonging to the true province of constitutional law. Their enunciation and study must, therefore, be left to the politician, and in this Course we must deal with the laws of the constitution proper.

LESSON TWO

Parliamentary Sovereignty in the State

We have already noticed one of the peculiarities of the English constitution, namely, that it is not the product of any preconceived plan. Another feature of great importance is what is called parliamentary sovereignty. Any law passed by the Parliament of the United Kingdom will be enforced by the courts.

At first sight this may not appear a surprising statement; it is when the English Parliament is compared with the Parliaments, or legislative bodies, of other countries that the unusual character of this sovereignty is made clear. In the constitution of the United States the most striking feature is not the sovereignty of any legislature, either Congress or a state legislature, but the supremacy of the constitution. Each of these legislatures derives its powers from the constitution, and can make no law which it is not authorized to make by the constitution. If the legislature passes any law, the courts may declare the law invalid because it is against the constitution. For instance, the Supreme Court so declared the National Recovery Act of 1933 to be null and void.

In England, however, the courts cannot in any case refuse to enforce a law on the ground that it is unconstitutional. Further, there is in Great Britain no law that cannot be changed by Parliament. In countries in which the legislature is not sovereign, but is under a constitution, the legislature has no power to change that part of the law which consists of the constitution. The power of changing the constitution in such states is placed in the hands of some body other than the legislature. For example, an amendment of the American constitution can be brought about with the consent of two-thirds of both houses of Congress and with the ratification by the legislatures of three-quarters of the states. One obvious result of this is a strong tendency to conservatism on all constitutional questions.

Complete Sovereignty of Parliament. Some illustrations of the complete sovereignty of the English Parliament may make the distinction clear. The Act of Settlement (1701) fixed the succession to the Crown in the House of Hanover, so that the king occupies the throne by reason of an Act of Parliament. When we recollect the fierce struggle that had taken place less than a century earlier to uphold the divine right of kings, the great significance of the change to a statutory right is made clear.

Parliament, by reason of this very sovereignty, is unable to bind future Parliaments, or to control its own future acts. A significant illustration of this is provided by the acts fixing the maximum periods for which one Parliament may sit. The Parliament Act of 1911, among other enactments, repealed the Septennial Act, and decreed that the maximum life of Parliament should be five years. This was intended clearly to be a protection for the electorate, so that it might have the right at frequent intervals of electing a body to represent its views, and should not be compelled to be ruled by a body in which it had lost confidence. Yet the same Parliament which passed the five-year decree extended its own life to eight years, in order to avoid a general election during the First Great War. Similar annual acts of prolongation were passed during the Second Great War by the Parliament elected in 1935; and it would be perfectly legal for any Parliament to pass a law that its life should be extended to twenty years.

This same power of lengthening its own life was exercised by Parliament in 1716. At that time the duration of Parliament was limited to three years, and an election was due in 1717. The 1715 rebellion was a very recent event, and the government of the day felt that a general election at that time might be very dangerous. Accordingly, Parliament passed an act providing that it should remain in power for seven years instead of three. In a country with a fixed constitution, in which the legislature is not sovereign, such a thing would involve a change in the constitution, and would be beyond the powers of the legislature.

Another striking illustration arises from the Statute of Westminster, 1931. This freed the Dominions almost entirely from the power of Parliament, and provided that Parliament should legislate for any Dominion only at its request and with its consent. Yet the Lord Chancellor has declared that Parliament could 'as a matter of abstract law' disregard this provision. Nothing can fetter the legal sovereignty of Parliament, not even its own decision to limit its powers.

We have thus seen, as one aspect of Parliamentary sovereignty, that Parliament has power to make any law; there is another aspect, namely, that no body in the state has power to make any law unless that power is given to it by Parliament. Claims have from time to time been put forward by bodies in the state other than Parliament to be entitled to make laws. The Crown for long claimed the right to make laws by means of royal proclamations. Royal proclamations are issued by the Crown at the present day, but it has been established for over three hundred years that they cannot make new laws, although they may be useful in times of emergency in calling the attention of citizens to laws that have been made by Parliament.

Orders in Council. The Crown does at the present day exercise a very wide power of legislation by order in council. It has become the practice for Parliament to pass Acts laying down merely broad outlines, and to confer upon some minister of the Crown power to provide for the necessary details by order in council. This power became prominent during the First Great War, when Parliament, by the Defence of the Realm Acts, conferred on ministers very wide powers, and it was even more freely exercised during the Second Great War. By an Act passed in 1920 the Crown may in a time of emergency make orders dealing with all matters necessary to protect life and property. This Act was used at the time of the General Strike in 1926. This is undoubtedly a very important modern development, particularly as the power can be used in peacetime, but it does not in reality set up the Crown as a rival to Parliament as a law-making authority, for such power as the Crown possesses is only through the delegation of Parliament, and must be exercised in strict conformity with the authority given. Thus it is open to the courts to say that an order in council is not good law because it is *ultra vires*—i.e. beyond the powers conferred by the particular Act of Parliament under which the order purports to be made. In this respect an order in council is similar to an act of the American Congress. At one time attempts were sometimes made to word the Act in such a way as to exclude the power of the courts to consider whether or not an order made under the act was *ultra vires*; but recent governments have not approved of this expedient.

The courts of law in this country have the task of declaring the existing law. They cannot change the law. Judges very frequently state this principle when bound by authority of some statute to give a decision which conflicts with their common sense—and the statement is true.

The judge's duty is, after an examination of the Acts of Parliament and a consideration of any previous relevant decisions of the courts, to decide the case before him in accordance with these statutes and decisions. The law as stated by him is considered to have been the law before his decision, and if in his decision he overrules any previous case, the result is not that the law is changed, but that the law is regarded as having been declared wrongly in the previous case.

It would no doubt be stated by a politician that the electorate is the true sovereign in the country, and that members of Parliament are merely the representatives of the electorate. However true this may be politically, it is not true legally, for no law passed by Parliament can be said to be illegal because it does not have the approval of the electorate. As has been pointed out, the member of Parliament is not now, in practice, a free agent, but is expected to record his vote in a certain way; any failure, however, of his to do so would not affect the validity of the vote. The electorate may influence the legislation of Parliament, but cannot legislate itself.

We have now seen that in this country Parliament is a sovereign body, and that this sovereignty has two effects—first, there are no limits in its power to legislate; secondly, it is the sole body with power to make laws, although this power can be delegated.

LESSON THREE

The Rule of Law in Principle and Practice

SOME of the fundamental principles of the English constitution may be summed up in the expression, ' the rule of law.' This has two meanings—first, that no man can in this country be punished except for a breach of the law, established in the ordinary legal manner before the ordinary courts; and, secondly, that every man, whatever his rank or official position, is subject to the ordinary law of the country and not entitled to have his case removed from the ordinary courts to some special court. In this country, in normal times, every man must be tried and found guilty *according to law* by a proper court before he can be punished, and, before he is tried, he must be informed of the nature of the charge against him. He is also entitled to a speedy trial, for otherwise the ends of the law might be defeated by keeping a man in prison without trial; and by the Habeas Corpus Act and the common law he must be brought at once before a magistrate on his arrest and, if no sufficient case is then made out for his arrest, is entitled to be released. In any event he is normally entitled to be released on bail until his trial, and, if bail is not allowed, to be tried at the first sessions after his committal.

Emergency Powers. For many years it had appeared so natural to a citizen of this country that he could not be arbitrarily punished and was entitled to a trial in a public court that it needed the emergency of a major war to make him realize the value of the principle. During the First Great War, under the Defence of the Realm Acts, 1914 and 1915, the King in Council was authorized to issue regulations which should have the force of parliamentary law, and the authorities were empowered to order the internment of persons of hostile origin and associations, and also to arrest suspected persons without a warrant. On the outbreak of the Second Great War the Emergency Powers (Defence) Act of 1939 (extended by the Emergency Powers Act of 1940) gave the King in Council similar power as to making regulations, and also provided that any person could be detained whose detention appeared to the Secretary of State to be in the interests of public safety. Regulation 18B, made under these Acts, went very far, and gave the Home Secretary power to detain indefinitely and without trial any person, British subject or not, if he had ' reasonable cause ' to believe the detainee was of hostile origin or associations or had been recently concerned in acts prejudicial to the public safety or defence of the realm, or was or had been a member of certain organizations, such as those whose leaders had ' sympathies with the system of government ' of any power with which we were at war. Anyone detained could apply to an advisory committee appointed by the Home Secretary, but the Home Secretary was not necessarily bound to act on the decision of the committee.

This imprisonment of citizens indefinitely without trial was very repugnant to many people in this country. No one doubted that the authorities must have wide powers of immediate detention of persons whose activities might be dangerous to the State; but many people felt that the detention should be followed by some sort of trial, held in camera if necessary, at which the detained person could have an opportunity of meeting the accusations levelled against him.

The courts interpreted Regulation 18B very widely, and the House of Lords held that it was not open to the courts to consider whether or not the Home Secretary had ' reasonable cause ' for the detention: it was conclusive if he stated that he had such cause. One famous law lord vigorously dissented from this decision, and stated that the arguments put forward on behalf of the Home Secretary 'might have been addressed acceptably to the Court of King's Bench in the time of Charles I' when the executive was at the height of its power in modern times.

The strong attacks made on this decision of the House of Lords by lawyers and others do, however, help to emphasize how violently our constitution is opposed to any power of arbitrary imprisonment.

'Reading the Riot Act.' The second of the two principles involved in the 'rule of law' is that every man is equal before the law. Any official, be he the governor of a colony, a Secretary of State or a police-constable, is responsible to every citizen; if he in any way infringes the rights of a citizen he cannot escape liability by showing that he was acting in obedience to the orders of his own superior officer, and cannot claim to have his case removed from the ordinary courts to some special court. Thus it is no defence to a soldier who has shot a man to state that he was ordered to fire by an officer in command. A soldier is, it is true, subject to laws different from those governing the ordinary citizen; thus acts which would be for the citizen either crimes of a minor character, or even no crimes at all, will involve the soldier in serious penalties. An obvious example is the striking of a superior officer. But in his relationship with the private citizen the soldier is in no privileged position.

It is interesting to note here the effect of what is called 'reading the Riot Act.' A body of troops called upon to quell a disturbance is not entitled to fire upon a crowd, except in very extreme cases; but if some magistrate can be prevailed on to read a proclamation prescribed by the Riot Act (not the act itself), every member of the crowd who does not disperse within an hour is automatically guilty of a felony, and thereafter any violence reasonably necessary may be used to disperse the crowd or arrest its members.

This 'reading of the Riot Act' is the nearest approach possible in English law in peacetime to what is known in France as the 'declaration of the state of siege,' which passes to the military power all authority required for the preservation of peace and ousts the jurisdiction of the ordinary courts.

Growth of Bureaucratic Power. The second principle under the 'rule of law' has also been encroached upon in recent years. In the first place, a great many tribunals have been set up by act of Parliament for the decision of matters which are for this purpose removed from the ordinary courts, e.g. claims to old age pensions. These tribunals usually consist of some official in a government department, which is thus made judge 'in its own cause,' and their growth has been viewed with alarm by many statesmen. Not only are these officials apt to be influenced unconsciously by the position which they hold, but also they are not bound in their inquiries by the ordinary rules of evidence as applied in the courts. Further, the Act of Parliament setting up such tribunals may declare that no decision of any of these officials shall be questioned in any court of law.

In conclusion, it may be pointed out that when, in a period of disturbance, acts have been done by troops or police in good faith and with the object of putting down disorder, but which have, in fact, resulted in the infringement of the rights of private citizens, provision is usually made for the protection of those concerned by passing an act of indemnity, *after* the event, which expressly confers immunity on them.

LESSON FOUR

Short History of Our Legislature

The most striking feature of the legislature of this country, and the attribute which has made it the model for democratic countries all over the world, is that it is a representative body, consisting of members chosen to represent, so far as possible, all interests and opinions. Of recent years representative government has reached in this country what may perhaps be regarded as its full extension in manhood and womanhood suffrage; but the principle of legislation 'by the people for the people' is to be found, though in a rudimentary form, very early in English history.

Famous Early Parliaments. While it was the custom of the Saxons and early Norman kings to hold councils of the great men of the land for the purpose of obtaining advice, these councils can in no sense be regarded as representative bodies. The king called to them such persons as he chose, and, at any rate in Norman days, the council consisted of the great landowners, who held land of the king as his feudal tenants, and the interests they voiced were their own and not those of the country as a whole. The first germs of a representative legislature are to be found in the Parliaments of the 13th century, notably in the famous Parliament of 1265, to which Simon de Montfort summoned representatives of the counties, cities, and boroughs, and in the Model Parliament of 1295.

The striking feature of these Parliaments is that they contained, side by side with the great men specially summoned by the king, persons selected by and sitting as representatives of others. Thus the electors exercised the right to choose some at least of those who assisted in the government, if they did not yet govern the land. To the Model Parliament Edward I summoned separately the two archbishops, the bishops, the greater abbots, seven earls, and 41 barons, and the clerics were directed to bring with them certain of the clergy in their dioceses. Also each sheriff was directed to cause two knights of each shire, two citizens of each city, and two burgesses of each borough to be elected. These representatives of the *communitates* or *communes*, i.e. communities of shires, cities, and boroughs, became the House of Commons (which does not, as is generally supposed, derive its name from the 'commons' or common people). In this Parliament we thus see for the first time a definite departure from a feudal council and the formation of a national assembly.

The writ requiring the attendance of the minor clergy was not long obeyed. The higher clergy met with the other great landowners in the body which has become the House of Lords. Another important feature of the Model Parliament is that the knights of the shire, who were drawn from much the same class as the barons, sat with the representatives of the cities and boroughs, and so there never arose in England that sharp cleavage between the nobility and the commons which developed in other countries.

The Middle Ages were not a time of great legislative activity, and so the main task of Parliament was the voting of money to the king. The king always enjoyed a large revenue from his own estates and the feudal dues, but if he wished to raise any further sums he could do so only with the consent of Parliament. Now, Parliament had its grievances from time to time, and when called together for the purpose of voting supplies, it usually endeavoured to strike a bargain with the king, demanding legislation to remove injustices—or further its own interests—in exchange for the vote of money.

By the end of the 14th century Parliament had established the right to impose taxes of all kinds, and in order that the king might be compelled to call Parliament at frequent intervals, Parliament usually refrained from imposing more taxes than were required to meet the immediate needs. At first, the Lords and Commons used each to impose separate taxes on their own orders, but before 1400 the practice had grown up of making a common grant, and gradually, since the largest burden of taxation fell upon those whom the Commons represented, the very important constitutional principle became established that money grants had to be initiated in the House of Commons, and that the king could not consent to them unless both Houses agreed. In other matters the Commons were at first petitioners for legislation rather than legislators themselves. Some early statutes are expressed to be made by the king with the *assent* of the earls, prelates, and barons, and *at the request* of the knights of the shire.

All statutes were at first framed by the king in his council in answer to some petition of the Lords or Commons, with the result that not infrequently the statute as framed did not meet the grievance of the petition; but by the reign of Henry VI the principle became established that the Lords and Commons should themselves frame the legislation they wanted in the form of a 'bill,' which they would present to the king. He could then accept or refuse it, but could not alter it. This change is marked by an alteration of the phraseology in the preamble to a statute, for thereafter statutes are stated to be made not only with the 'advice and consent of the Lords and Commons in Parliament,' but 'by the authority of' the same. Parliament no longer merely advised legislation, but actually initiated it.

Growth of Parliament's Supremacy. When we leave the Middle Ages and come to the time of the Tudors we find that Parliament is subjected to the will of strong monarchs such as Henry VIII and Elizabeth, who do not overrule Parliament, but rule as they please through Parliament. When James I came to the throne he lacked the ability to manage his Parliaments in this way, and many constitutional questions which had been evaded by his more tactful predecessors came into sharp prominence. The quarrels that arose out of these under the Stuarts resulted in the victory of Parliament when the Hanoverian succession was established, and the king became king and held his throne by virtue of an Act of Parliament.

The 18th century saw the rise of the great Whig families and the development of the 'pocket boroughs.' The latter were finally swept away in the great wave of reform in the 19th century, by the Reform Act of 1832. From that time the changes have been rather in the electorate than in Parliament itself, and in the growth and development of the Cabinet system linking legislature and executive. The most important changes in Parliament itself have been the increased supremacy of the House of Commons over the House of Lords—culminating in the Parliament Act, 1911, which made the Commons the sole legislative authority in certain cases; the admission of women to sit in the House of Commons (1918); and the payment of an annual salary to members of the lower House (1911).

Parliament is today a permanent institution, sitting continuously with only short vacations. In normal times it is dissolved at definite intervals, when a general election takes place. Formerly, however, Parliaments were both infrequent and irregular in duration. If Parliament favoured the king, he might retain it for many years; if it opposed him, he could dissolve it at once, and call no other. In 1694, however, the life of Parliament was limited to three years, extended in 1716 to seven, and reduced in 1911 to five (*see* page 472). There is still no statute which requires the king to call Parliament every year, but if he did not do so, he could not govern, for he could have no army and no taxes, since the Mutiny Act, which authorizes the army, and the Finance Acts are passed to last for one year only, and have to be renewed annually.

LESSON FIVE

The Privileges of Parliament

FROM what we have hitherto said it might, perhaps, appear that the House of Commons has stood for freedom against the tyranny of the Crown. This, however, would not be a true representation of the facts, for the Commons, in their struggle with the Crown, were not consciously asserting the rights of the people or of freedom, but were striving to establish the power of their own House against king and people alike. From these struggles the House has emerged with certain privileges, which it asserts against all those outside itself. At the beginning of every Parliament the Speaker, on behalf of the House, claims these privileges, in his address to the Lord Chancellor, as 'ancient and undoubted' privileges, and the Lord Chancellor, on behalf of the Crown, most readily grants and confirms them.

Every member is privileged from arrest during the continuance of the session and for forty days before its commencement and after its conclusion. Formerly the privilege of members extended to protect not only the member himself, but also his goods; but now it is limited to the member himself, and does not apply to indictable offences (the majority of serious criminal offences), or to contempt of court or to offences against emergency regulations such as Regulation 18B, referred to in page 474. The reason for this privilege is obvious, namely, that the State should not be deprived of the services of the members on whom its safety might depend.

Freedom of Speech. An even more important privilege is that of freedom of speech. This is clearly a question upon which much dispute was likely to arise between the Commons and the Crown, and, accordingly, so early as 1397, we find the king, Richard II, rebuking the Commons for adopting a bill to reduce the charges of the royal household. Under the Tudors and early Stuarts members whose speeches were obnoxious to the Crown were summoned before the Council and sent to prison. A general privilege of freedom of speech was recognized, but it was interpreted by the Crown to mean a privilege 'not to speak everyone what he listeth or what cometh in his brain to utter; but your privilege is "aye" or "no".' A privilege of this extent was not of great value, and the struggle went on until the Bill of Rights after the 1689 revolution finally declared that the freedom of speech in Parliament should not be questioned in any court or place out of Parliament. The wide extent of this privilege will be recognized when it is remembered that no action for defamation of character can be brought on any words spoken in Parliament, and this explains the invitation occasionally made by a member whose character has been attacked by another to 'repeat the statement outside the House,' when proceedings could be taken for slander. A privilege so great is obviously liable to abuse, and so the House itself imposes a restraint upon its members, who may be expelled, fined or committed to prison in serious cases, or, in minor cases, asked to withdraw from the House, or suspended.

Secrecy of Debate. In early times the right claimed by the members to say what they pleased had a not unnatural corollary in the claim to exclude from the House all persons who were not members, and who, if admitted, might carry reports of what was said to the king. Secrecy of debate was as necessary as freedom of speech. Until 1875, if any member called the Speaker's attention to the fact that strangers were present, the Speaker was obliged to cause them to withdraw; but as newspaper reporters were (and are) technically strangers, the rule was somewhat inconvenient, and in 1875 it was altered so that the strangers are not required to withdraw unless the House so resolves. During the agitation for woman's suffrage, and in 1920 after the disturbances in Ireland, strangers were excluded, and secret sessions are held for security reasons during wartime; but in normal times any person can obtain admission to the Strangers' Gallery on making application.

This policy of secrecy as to how members spoke and voted has, naturally, had a considerable bearing on the publication of reports of debates. At present, except of course when the House is in secret session, full reports of all debates and votes are published, and members are called to answer to all sections of a critical electorate for the most minute deeds—or misdeeds, according to the point of view—of their time in the House. In the 18th century the country as a whole, and London in particular, became much interested in the doings of Parliament; and as Parliament afforded no facilities to enable accurate reports to be made, reporters relied on their inventive faculties, their reports consequently gaining in scurrility what they lost in accuracy. The great Dr. Johnson was on one occasion the 'reporter' of an oration which gained temporary fame for a member, though the words in it had never been uttered by him. In 1771 the House committed the Lord Mayor and two aldermen to the Tower for having refused to obey the orders of the Commons to arrest a printer of debates, but thereafter the House admitted reporters on sufferance, probably to save itself from the inaccuracies of inventive journalists.

Publication of Speeches. Although, as we have seen, whatever a member might say in the House was privileged so far as proceedings for defamation were concerned, it is still technically a breach of the privileges of the House to publish outside the House reports of speeches, although such reports have for long been permitted. Reports of the proceedings of the House, taken from the newspapers, began to be printed in the eighteenth century by the family firm of Hansard, whose name was for long colloquially and is now officially applied to the official parliamentary reports published daily when the House is sitting.

On one occasion, in 1837, Hansard was sued for publishing a defamatory libel contained in a report published by order of the House. The courts held him liable, but the House was very indignant at what it considered an infringement of its privileges, and an act was passed in 1840 preventing proceedings in such cases. Freedom of report is obviously in the interests of the large public which depends on statements in the House for its knowledge of affairs at home and abroad. A report of the actual proceedings of either House is free from attack on the grounds of libel, even though it is not authorized by the House, so long as it is fair and accurate, and published without malice, and this it is which protects the reports of Parliamentary proceedings that appear in the daily press. If, however, a member makes an attack on a person by a speech in the House, he is no way protected if he afterwards publishes the speech outside the House.

These privileges of the House would be of little value if some method did not exist of punishing those who fail to observe them. The punishment of members has already been considered. The House punishes strangers by admonition, reprimand or commitment, i.e. imprisonment. A person admonished may escape further punishment by an apology to the House. If a person is to be reprimanded he is first arrested by the Sergeant-at-Arms—the 'policeman' of the House—and then brought before the House. The House cannot imprison for longer than the duration of the session.

The House is jealous of its privileges, and complaints that they have been infringed are not infrequent. The matter does not come before the ordinary courts. If the Speaker decides that a *prima facie* case has been made, the matter is considered by a committee of the House which in due course reports to the House. The matters which most frequently give rise to complaints are: any attack on the Speaker or Chairman of Ways and Means, particularly any suggestion that they are not impartial; and any libel on the House as a whole or any libel on any individual member, so long as it reflects on him in respect of his conduct in the transaction of the business of the House.

The Constitution of Parliament. Parliament consists of the King (or Queen regnant), the Lords Spiritual and Temporal (House of Lords), and the Commons (House of Commons). Of the two Houses, the House of Commons is today by far the more important, not only in practice, but also, as we shall see, in theory, and it is, therefore, more convenient to devote to it our first consideration.

The House of Commons (1945) consists of 640 members elected by constituencies in England and Wales (553), Scotland (74), and Northern Ireland (13). Generally speaking, every county or borough which has a population of between 50,000 and 70,000 returns a member, and larger counties or boroughs are divided up into units containing from 50,000 to 70,000 of population, each returning a member. In one or two cases a larger constituency is formed which returns two members. There is no doubt that this system of single-member constituencies does not provide an adequate representation of minorities, and a party which, in the country, has secured 40 per cent of the total votes may find that, in the House of Commons, it is represented by 10 per cent, or even less, of the seats. Thus even if a party had only a small majority of the electorate in its favour it would probably find itself represented in the House by a large majority of the members; and if there were three or more candidates in most of the constituencies, a party which had polled less than 50 per cent of the total votes might gain the majority of seats.

Representation of Minorities. There is a division of opinion as to whether this misrepresentation is tolerable or deplorable, for many persons consider that it ensures that the country shall have a strong government, with sufficient power in the House to carry out its programme, and prevents the development of government by a coalition of small groups, which is so frequent on the Continent. The remedy most usually advocated by those who consider the system undesirable is proportional representation. This involves the creation of large constituencies, each returning three or more members. The voters in each constituency do not merely vote for one candidate, but place the several candidates in order of preference. The various preferences are then counted and the required number of members declared elected. By this means, it is contended, the House of Commons would more accurately represent the state of feeling in the country.

Today almost any man or woman who is a British subject of full age is qualified to be a member of Parliament. The principal exceptions are bankrupts; clergy of the Church of England, the Church of Scotland, and the Roman Catholic Church; peers (except certain Irish peers); and the holders of certain offices under the Crown. The last of these disqualifications is of great historical importance. At one time the House of Commons, when engaged upon its struggle with the Crown, was much concerned to prevent the Crown gaining favour among its members by gifts of pensions and profitable offices, and, accordingly, a law was passed declaring that on the acceptance of such office a member lost his seat. As cabinet government developed, the danger from the Crown grew less, and the rule caused great inconvenience, since it required that on every appointment of a member as a minister of the Crown there should be a by-election. In 1919 this rule was relaxed to the extent that any minister appointed within nine months of a new Parliament could retain his office without re-election. In 1926 the rule was finally swept away so far as ministers were concerned. Other servants of the Crown, such as judges, civil servants, and members of the royal forces on the active list, are still incapable of sitting. During wartime provision was made to enable members of the Forces to sit, and if the Prime Minister (as First Lord of the Treasury) certified that the appointment of some person to some special office was in the public interest, that person might hold the office without losing his seat. The House regarded this extension of the power of the executive as justified only by the exigencies of war.

Once a member has been elected to the House of Commons, it is not possible for him to resign. This rule owes its existence to the fact that in early days membership of the House was a duty rather than a privilege, and a member called on to sit was required to do so. Today, however, a member is able to vacate his seat by an ingenious use of the rule imposing disqualification upon Crown servants. Any member wishing to resign now applies for an office under the Crown of purely nominal importance, with no duties. The office usually selected is the Stewardship either of the Chiltern Hundreds or of the Manor of Northstead. The Chancellor of the Exchequer makes the appointment as a matter of course, the member automatically vacates his seat, and, having achieved his object, resigns his newly-acquired office.

Parliamentary Franchise. Having considered the members themselves, let us now turn to those who are entitled to elect them. Every man and woman over 21 years old is entitled to be registered as an elector if he or she has certain qualifications. The first is the qualification by residence. In addition, persons who carry on a business are entitled to vote in the constituency in which their business premises are situated, and members of a university have a vote on the election of the member for the university. A person may have several voting qualifications, but he cannot exercise them all; the rule is that he may vote for his residence and for any one (but only one) other qualification. Peers of the realm cannot vote, on the ground that they are already entitled to sit in the House of Lords and so are not entitled to any further representation. Aliens are also disqualified. A person is no longer disqualified from being registered or from voting on the ground that he is in receipt of poor relief.

The register is prepared annually. During the Second Great War the preparation of the annual registers was suspended. By 1945 for various reasons a very large number of people had come to reside in districts other than those in which they were living in 1939, but they could not acquire any right to vote in their new constituencies because no new register was prepared. A special register was therefore prepared in May 1945 and was used in the 1945 general election. Civilians were entitled to be placed on this register for any constituency if they were registered under the National Register (i.e. on their identity cards) as residing in that constituency. Persons claiming a business premises qualification had to apply to be registered. Persons in the services and some others could vote by post or by proxy.

The House of Lords. The House of Lords is presided over by the Lord Chancellor, and consists of (1) the Princes of the Blood Royal who are peers (e.g. the Royal Dukes), (2) about 700 hereditary peers of the United Kingdom; (3) the two archbishops, the bishops of London, Winchester and Durham, and the 21 most senior of the other bishops; (4) sixteen peers, who are peers of Scotland, but not of the United Kingdom, elected by all the peers of Scotland, for the duration of each Parliament; (5) Irish peers, who are not peers of the United Kingdom, elected by the body of Irish peers for life (originally 28 peers were elected, but since the creation of the Irish Free State no new elections have been made); (6) seven 'law lords,' who are salaried judges, and are entitled to the rank of baron for life. The peers are entitled to individual summonses from the King, and it is now recognized that if any person can prove he is the direct descendant and heir of a person who received such an individual summons, he is entitled to the rank of peer.

Today peers are created by letters patent under the Great Seal, and the King still exercises the power of appointment. This power has occasionally been used, as a threat, by ministers of the Crown in order to induce the House of Lords to accept a measure which has been passed in the House of Commons. Thus, in 1911, Mr. Asquith, then Prime Minister, secured the passage through the Lords of the Parliament Act of that year, which definitely established the supremacy of the House of Commons over the House of Lords, by threatening to ask the King to create a sufficient number of new peers favourable to his policy to ensure a majority in the Lords. The Lords submitted.

The reform of the House of Lords has frequently been a live topic in politics, but, like many other threatened institutions, the House of Lords has preserved its constitution unchanged, although it has lost some of its powers. On paper it would appear to be about the most cumbrous and inefficient legislative body imaginable, but in practice it works very much better than might be expected. The vast majority of the peers never trouble to take their seats, and those who do attend constitute a workable assembly, including men who have proved their ability in all branches of life and who can deliberate impartially to an extent rarely possible for the member of the House of Commons, who is much more likely to be carried away by temporary changes in public opinion, and who must frequently consider the effect which any speech of his is likely to have upon his constituents and upon the possibility of his losing his seat at the next election.

LESSON SIX

The Making of Our Laws

In general, Acts of Parliament do not become law until they have received the approval of both Houses of Parliament and the King's assent. Exceptions arise from the Parliament Act, 1911, which secured the undivided authority of the House of Commons over finance, and its predominance in all legislation. In the case of bills dealing with finance—money bills—if the bill is passed by the Commons and not by the Lords, within one month it becomes law on receiving the Royal Assent, and the approval of the Lords is dispensed with. We have already seen that no money bill can be initiated in the Lords. If a bill other than a money bill is passed by the Commons in three successive sessions and three times rejected by the Lords, it will nevertheless become law on receiving the Royal Assent, provided that two years have elapsed between the second reading of the bill in the Commons in the first session and its final passing in the third session. It would be a mistake to imagine that the Lords have lost all effective legislative control by reason of the Parliament Act. In fact, no House of Commons would venture to rely on the provisions of that act—at any rate in the case of bills other than money bills—unless they were assured of a large majority in the country in favour of their policy, and in such a case would probably prefer to go to the country on the issue of the disputed bill. If the country then supported the policy of the bill, it is improbable that the Lords would continue their opposition.

The House of Commons at Work. Let us now picture the ordinary working of the House of Commons, and trace a bill from the time when it is first introduced until it receives the Royal Assent and becomes an 'Act of Parliament.'

At the beginning of the sitting the Speaker enters the house, preceded by the Sergeant-at-Arms with the mace. The Speaker takes the chair and the mace is laid on the table. A quarter of an hour is devoted to the consideration of bills introduced by private members (i.e. members not included in the Government), and then comes 'question time.' Inquiries are addressed to ministers of the Crown, designed to inform the members (and, through the medium of the press, the whole country) as to how the ministers have been exercising their powers as the executive of the Crown. The answers may be given orally if desired. When question time has expired, questions that have not been answered orally are answered in writing.

The importance of questions becomes greater every year, for so heavy is now the pressure of work to be carried out by the Government that the time of the House available for private members is very small, and questions are the only method by which matters of great importance outside the ordinary business may be brought to the notice of the House. For this purpose any member may move at the end of question time that the House be adjourned 'for the purpose of discussing a definite matter of urgent public importance,' in which the conduct of a minister is involved. If the Speaker decides that the matter is definite and urgent, and the motion is supported by not fewer than forty members standing up from their seats, it is allowed to be proposed. If it is carried, the discussion takes place later on the same day. The next business is giving notices of motion, in which way new bills are introduced, and thereafter the House proceeds to Orders of the Day.

Stages of a Bill. When a member desires to introduce a bill, he first gives notice of his intention to do so. This is usually formal, but if it is opposed, a discussion may take place and, on a division, leave to introduce the bill may be refused. If not, the bill is immediately presented by the member introducing it, and the Clerk of the House reads its title aloud. The questions that the bill be now read a first time and be printed are then put, no debate or amendment taking place, and it is ordered that the bill be read a second time on a later day.

The bill then comes on as part of the Orders of the Day, and a general discussion ensues on the motion that the bill be read a second time. If it passes the second reading, it is committed to one of the Standing Committees of the House. In the case of bills imposing taxes, or Consolidation Fund or Appropriation bills, and bills for confirming Provisional Orders, the bill is referred to a committee of the whole House. On such occasions the Speaker leaves the chair without question put on each day when the bill is one of the orders of the day, and the Chairman of Committees takes his place. To whatever committee the bill is referred, it is there discussed in great detail, clause by clause, by the members forming the committee. When the bill has been fully considered, the chairman of the committee reports it to the House, when it is then considered on the report stage. Amendments may be made, but if they are complicated the bill will be sent back to the committee to have them discussed and embodied in the bill. At the conclusion of the report stage the motion is made that the bill be read a third time, and when this is carried, the House orders the Clerk to carry the bill to the Lords and 'desire their concurrence.'

The Speaker's Powers. The Speaker has very wide powers of control over the House. It is his duty to certify whether a bill is or is not a money bill for the purposes of the Parliament Act, and in the House itself he can request a member to withdraw if he is disorderly, and if the offending member refuses to do so, he may be named and a motion will thereafter be made for his suspension. The Speaker must necessarily be completely impartial, and though he is selected by the Government in power when a vacancy occurs, all parties are consulted on the appointment. During his tenure of the chair the Speaker is free from all party ties, and takes no part in discussions. At election time he is by agreement usually not opposed in his constituency.

It is convenient here to notice the special procedure known as the 'closure' and the 'guillotine.' The former was introduced in 1882 to combat the obstructive methods of the Irish Nationalist members, who, by prolonging the discussion of bills, were deliberately bringing business to a standstill. Under the closure the debate can be cut short at any time by a member rising and proposing that the 'question be now put.' Unless the Chair decides that the motion is an abuse of the rules of the House, or an infringement of the rights of the minority, the question is put without amendment or debate. The guillotine is a far more drastic means of curtailing debate. By this method certain times are by resolution of the House devoted to certain stages of a bill, and at the end of the time allotted for each stage discussion is closed, whether concluded or not. This unsatisfactory procedure is now often made necessary by pressure of work.

When a bill is sent from the Commons to the Lords, the procedure in the Lords is very much the same as in the Commons. If the Lords accept the bill, it is sent at once to the King for his assent; if they propose any amendment, the bill is returned to the Commons, where the House may accept the amendments. If it does not, negotiations take place between the party leaders in the two Houses until agreement is reached. For all practical purposes the bill is then law, for it is almost inconceivable that the King would today refuse his assent to a bill which has passed through both Houses.

LESSON SEVEN

The Executive in the British State

PARLIAMENT is the body by which laws are proposed and made; it is necessary, however, not only to make laws authorizing acts to be done but also to do the acts so authorized, and this is one of the duties carried out by the executive. Parliament may make a grant for the building of new battleships, but the orders for the ships will be given, and the work controlled, by the department of state called the Admiralty. In times of emergency, also, the executive exercises a wide power of authorizing acts to be done by its members; but this power, as we have seen, is delegated to it by Parliament.

In this country the executive consists of the various ministers of the Crown who are at the head of the different government departments. These ministers are in normal times all members of Parliament, although in time of war a person of special qualifications who is not a member of either House may sometimes be chosen to occupy a special post (e.g. the Rt. Hon. R. G. Casey, D.S.O., M.C., of Australia, appointed H.M. Minister of State, Middle East, in 1942); and in modern practice the chief of them—the Prime Minister—is a member of the House of Commons. Policy is determined by the cabinet, a body of upwards of 20 ministers, selected by the Prime Minister. In time of war a still smaller group—a war cabinet—may be formed. If the policy of the ministry does not meet with the approval of the

Houses of Parliament, a vote against them will be registered there, and, according to constitutional practice, they will be required to tender their resignations to the King. Another group of ministers may then take office; but if they cannot command a majority in the Parliament (today one must say, in the House of Commons), they must also resign. It is always open to ministers, instead of resigning, to 'go to the country'—i.e. to hold a general election, and this they will do when they consider that Parliament, in rejecting them, is not acting in accordance with the wishes of the electorate. Thus, while the ministers are in theory the King's ministers, and do all acts in his name, they are in fact answerable not to him but to the Houses of Parliament. An executive of this kind is known as a parliamentary executive. In some countries—notably the United States of America—the executive is 'non-parliamentary': that is, it is not answerable to the legislature for its acts, and may continue in office even though its policy conflicts with the views of the legislature. The President of the United States is elected at a special election quite apart from those which appoint the Congress, and members of the cabinet cannot be members of either House of Congress, nor are they allowed to speak in Congress.

The position in the United States immediately after the First Great War is one very difficult for Englishmen to understand. President Wilson committed himself at the Versailles Conference to support the League of Nations, and, although on his return he found that his idea no longer commanded the necessary two-thirds majority in the American Congress (*see* Modern History, Vol. VI, p. 103), he yet continued to hold office long after his policy had been repudiated. In this country no Prime Minister would commit himself on any question of policy unless he considered that he had the support of a majority in Parliament to give effect to his decisions, and if he did not, in fact, secure that majority, he would be compelled to resign, at any rate when a major matter was involved.

Growth of Ministerial Power. A parliamentary executive in England is of comparatively recent growth, for until the Revolution of 1689 the ministers of the Crown were not members of the House of Commons, and such control as the House enjoyed over them was by the right of impeachment, which entitled Parliament to try ministers of whose policy they disapproved. This right was exercised frequently during the 17th century, and Stuart Kings on several occasions dissolved Parliament in order to save a minister. The famous seven-year trial of Warren Hastings (1788–95) was on an impeachment. When the principle became established that the King's ministers must command a majority in the House of Commons, the procedure of impeachment fell into disuse.

Another striking feature of the executive in England is that the King leaves all the acts of government in the hands of his ministers, and all questions of policy are decided upon by the Prime Minister and his cabinet. At first, even after it had become understood that the executive should enjoy a majority in the House of Commons, there was no reason why the King should not meet with his ministers and discuss matters of state. That the system of cabinet government ever grew up is said to have been due to the fact that, as George I could speak no English and Sir Robert Walpole could speak no German, the King never attended the meetings of his ministers. Be that as it may, it is certain that from his accession the practice of the King's attending cabinet meetings fell into disuse. This led to the necessity of having some person to preside at cabinet meetings, and the person presiding came in the course of time to be known as the 'Prime Minister.' There was no such office known to the law until 1937, when the Ministers of the Crown Act was passed providing (inter alia) for payment to 'the person who is Prime Minister and First Lord of the Treasury' of an annual salary of £10,000. As a result of the system of cabinet government, the powers which the King used formerly to exercise himself 'with the advice of his ministers' have been in effect transferred to a committee of ministers.

Cabinet Responsibility. One of the most important principles of the cabinet is what is known as 'collective responsibility.' The members of the cabinet may not agree on some question of policy, but this disagreement is not disclosed to the public, and the decisions of the cabinet are those of it as a body, for which all members must accept responsibility, even though they may have been opposed to the decision when the question was discussed. If any minister wishes to escape this responsibility he must resign his office. This rule follows as a practical consequence of the rule that in normal times all ministers must be members of the same political party, and is also made necessary by the principle that all members of the cabinet are bound to secrecy as to its deliberations. If it were possible for a minister to escape from the consequences of a decision of the cabinet by saying that he was not consulted, or had not agreed, this secrecy would be lost. It is the fashion today to advocate publicity in everything, but the result of such a policy in cabinet discussions would be to destroy the present system of government and to weaken the effect of decisions of the Government in both home and foreign affairs.

If, as can happen, a ministry is formed which does not command an absolute majority in the House of Commons, its existence is rendered precarious by uncertainty as to how many, if any, votes of members not attached to its party its measures will carry. At the general election of 1885, for instance, the Liberals had a majority of 80. But if the 100 members for Ireland who then sat in the House of Commons had elected to vote with the Conservatives, Gladstone's government would have been defeated. In the event he was defeated on his first Home Rule Bill, not by the Irish, who supported it, but by a group of 93 dissident Liberals, calling themselves Liberal Unionists, who voted with the Conservatives against the bill. Again, the second Labour Government (1929–1931) could not carry any measures without the support of votes from other parties. There ensued an unsatisfactory system of 'bargains' on particular matters, the Liberals undertaking to support some government measure of which they did not wholly approve, if the Government would introduce some measure particularly desired by the Liberals.

One interesting development of the Constitution lies in the relaxation of the rule that a ministry must resign if defeated on any motion in the House of Commons. It is now recognized that defeat involves resignation only when the question is one of some vital matter of policy. This relaxation illustrates once again the principle that the Constitution of this country is flexible so far as the conventions of the Constitution are concerned, and may be changed as circumstances require without any formal act.

LESSON EIGHT

The King's Place in the Constitution

FROM what has been said in the previous Lessons in this Course it might be thought that the Crown, whatever powers it may at one time have enjoyed, has either been compelled to hand over these powers to the Judiciary or to Parliament, or in those matters in which it still in theory retains a say, has been forced to act on the advice of its ministers. This view, however, is not correct and is founded on a confusion between the 'King' and the 'Crown.' It would be helpful to think of a king as a natural person, still exercising some few of the powers of government, and of the Crown as a legal idea, a collection of rights, exercised today for the most part not by the King but by his ministers. The powers of the Crown have been reduced gradually throughout the history of the last thousand years, and, as we have seen, powers formerly exercised by the Crown—such as the right to make laws—have been taken from the Crown and given to another body in the state. The rights of the King have also been reduced, for by constitutional practice today he is not entitled to exercise in person even those powers which undoubtedly belong to the Crown—e.g. the control of the armed forces—but must act on the advice of his ministers. It is important to keep clear in one's mind this distinction between the King and the Crown.

The King's Parliamentary Title. The King holds his title by virtue of an Act of Parliament, the Act of Settlement (1701), as amended by His Majesty's Declaration of Abdication Act, 1936. The Act of Settlement was passed when it seemed certain that the provisions for succession to the Crown contained in the Bill of Rights, 1689, would prove insufficient. Of the persons mentioned in the Bill of Rights, Mary (daughter of Charles II) was dead leaving no issue, William III, her husband, was very ill, and Princess Anne (who later succeeded as Queen Anne), was without living issue and unlikely to have more children. The Act of Settlement, therefore, continuing the exclusion of the main line of the Stuarts and Catholicism, provided that the Crown should pass, in default of issue of William III or the Princess Anne, to the Princess Sophia of Hanover, a granddaughter of James I, 'and the heirs of her body, being Protestants.' When Queen Anne died, the Princess Sophia was already dead, but her son succeeded as George I. The Act also repeated the provision contained in the Bill of Rights that no Roman Catholic nor one married to a Roman Catholic should be allowed to inherit the Crown. The Act also stipulates that the Sovereign must be in communion with the Church of England.

The Abdication Act 1936 gave effect to the declaration of abdication by King Edward VIII and provided that he should cease to be King and that George VI, as the member of the royal family next in succession to the throne, should succeed him.

There was for a long time no statute prescribing the procedure to be followed should the King be incapacitated, as by illness or by being an infant or a lunatic. When George III became insane in 1810 the question arose as to whether the Prince of Wales, later George IV, was entitled to act as regent as of right, or whether it was necessary to pass an Act of Parliament appointing him. The question was never actually decided, but an Act of Parliament was in fact passed giving him the necessary powers, and the royal assent to this Act was dispensed with, and a resolution of both Houses was passed authorizing the Lord Chancellor to affix the Great Seal to a commission to give the necessary assent.

When George V came to the throne in 1910, his heir was only sixteen, and a Regency Act was passed making Queen Mary regent should the King die while his child succeeding him was under eighteen; and during the serious illness of George V in 1928 a Commission of State was appointed by the King to hold meetings of the Privy Council and sign documents on the King's behalf. The Commissioners' powers were limited in that they could not dissolve Parliament or create peers or do anything of which they had reason to think the King would not approve.

On the accession of King George VI in December 1936 the heir to the throne was Princess Elizabeth, then only ten years old, and in 1937 another Regency Act was passed, this time of a permanent nature. This provides for a regency during any time that the sovereign is under 18, and also during any time that the sovereign is totally incapacitated or for some definite cause not available. The regent will be the person next in succession to the Crown unless he (or she) is disqualified—e.g. by being under age. The regent may exercise all powers of the sovereign except that of consenting to a bill changing the succession or altering the Presbyterian Church in Scotland. The incapacity of the sovereign must be declared in writing by any three or more of the following:—the wife or husband of the sovereign, the Lord Chancellor, the Speaker of the House of Commons, the Lord Chief Justice, and the Master of the Rolls. Should the sovereign be absent from the United Kingdom or ill without being totally incapacitated, there will of course be no regent, but the sovereign may 'in order to prevent delay or difficulty in the dispatch of public business', delegate such of his powers as he thinks fit to Counsellors of State. These will be the wife or husband of the sovereign and the four persons next in succession to the Crown (excluding minors). When King George VI visited Canada in 1939 the five counsellors appointed were, accordingly, the Queen, the Duke of Gloucester, the Duke of Kent, the Princess Royal, and Princess Arthur of Connaught. The appointment of the Queen seemed curious, as she accompanied the King on his tour, but it was necessary because she was expressly named as a counsellor by the Act. This defect in the law was amended in 1943, and the Sovereign may now exclude from the Counsellors of State anyone who is or intends to be absent from this country at the time of the Sovereign's absence. During the King's visit to North Africa in 1943 the counsellors were the Queen, the Duke of Gloucester, the Princess Royal, Princess Arthur of Connaught, and her sister Lady Southesk. In the end of that year, when Princess Elizabeth was nearly 18, the Act was further amended to allow the heir to the throne to act as a Counsellor of State on reaching 18 instead of 21.

There is no general rule governing the position of the husband of a Queen Regnant. Philip of Spain who married Mary Tudor became 'King' during the marriage. The husband of Queen Anne remained Prince George of Denmark. When Queen Victoria married Prince Albert he was naturalized, but only twenty years later was he made Prince Consort.

At one time the death of the King had the effect of bringing to a standstill the whole government of the country. Parliament was automatically dissolved, the judges ceased to hold office, and the Privy Council could not meet. In very early times the result was even more disastrous, for the 'King's Peace' was considered to come to an end, and so no acts of violence could be treated as crimes. Today none of these results follow.

Just as the powers of the King are distinct from those of the Crown, so the King as an individual enjoys private property of his own. Formerly, he was expected to meet all the expenses of the country out of the revenue he received from the feudal dues, and his inability to do so and the consequent necessity of applying to Parliament for funds, was, as we have seen, the chief reason for the growth of the power of that body. Now, at the beginning of each reign, Parliament votes to the King an annual sum for his own personal use and for the upkeep of his establishment, and he in return gives up to the country certain revenues drawn from hereditary Crown property. He has in addition, of course, property in the same way as any of his subjects, and this is his own to use in the same way as any other citizen. Allowances are also made by Parliament for the private use of certain other members of the Royal Family.

The work which the King does is largely of a formal character and consists in the signature of a large number of documents on the advice of some minister. It would be a mistake, however, to regard the King as nothing more than a figure-head. Although the responsibility of making decisions lies in all cases on the minister and not on the King, yet the fact that the royal signature is required in so many cases tends to make communications between the King and the ministers of the Crown more frequent than they would otherwise be and keeps the King in touch with affairs. The extent of the influence of the King is, of course, a personal matter, but a monarch like Queen Victoria, who was in the closest touch with her ministers throughout her reign, could always give them the benefit of an experience in government far greater than their own.

The King cannot, of course, compel his ministers to accept his advice, but he enjoys a somewhat vague right of being informed of, if not consulted as to, acts of importance. Queen Victoria insisted on this right with considerable force, and had a serious quarrel with Lord Palmerston in 1851 for his failure to inform her of actions he proposed to take. There is no doubt that the Queen was right, and Bagehot has expressed the extent of her powers when he says that a constitutional monarch has three rights, ' the right to be consulted, the right to encourage, and the right to warn.'

King and Premier. There are today very few matters on which the King can be said to be entitled to act on his own initiative. There is still some doubt, however, as to whether the King, when a new Government is about to be formed, is bound to take the advice of the retiring Prime Minister as to which person in the Opposition shall be asked to form the Government and act as the new Prime Minister. There seems to be no reason why the retiring Prime Minister should be entitled to select his successor from among his rivals. A more important question is whether a Prime Minister has a ' right ' to insist on the dissolution of Parliament. Within the last hundred years the right of the King to refuse has been recognized. The question is not likely to arise, of course, so long as there are two major parties in the country, for on a dissolution one or the other is almost certain to obtain a majority which will enable it to form a Government. But if a number of more or less evenly balanced parties were to develop, a Prime Minister who had been unsuccessful in trying to govern with a minority in Parliament might justifiably be refused a dissolution, for too frequent general elections are very disturbing to the life of the country. The fact that this question is in doubt illustrates once more the flexibility of our constitution.

The Crown in the Twentieth Century. Recently the Crown, after suffering great losses in the struggle with Parliament when its powers were still exercised by the King, has now, when they are exercised by ministers, recovered a not inconsiderable part of its losses. It is true that the powers of legislation of the Crown are delegated to it by Parliament, but under our present system of government Parliament does very much as the ministers in power wish, and so these ministers are enabled to take, for the permanent departments which they represent, powers of legislation of an absolute character. Further, Parliament is itself a much overworked body and therefore only too willing to delegate to the ministers the task of filling in the details in a scheme of legislation, Parliament contenting itself with laying down the general principles. The Crown's power of legislation, however, has gone much further than this, for statutes have enabled ministers to amend Acts of Parliament as they please and have provided that such amendments shall have the same effect as if they were contained in the original Act.

Civil Servants as Judges. Not only has the Crown enjoyed considerable success in its recent struggles with Parliament, but it has also invaded the sphere of the judiciary, and has attacked what was once considered one of the primary principles of our constitution, namely, that all persons were entitled to have their disputes determined before the judges not under the control of the Crown. So it happens that questions of great importance to the subject, and even cases between the subject and the Crown, are removed from the ordinary courts and are decided by civil servants in a government department. For example, the granting of old age pensions is so decided, with a very limited right of appeal to the courts. It is probably too late to oppose this tendency to remove cases from the ordinary courts, and many people would, indeed, like to see it extended—e.g. to claims under the Workmen's Compensation Act—but steps should certainly be taken to ensure that those who try the cases on behalf of the Crown should have adequate legal training and follow uniform principles in procedure and evidence, although not necessarily those of the courts of law. In 1929 a committee on ministers' powers was set up by Lord Sankey, largely as a result of the violent attack on the judicial powers of the government departments contained in 'The New Despotism,' by the Lord Chief Justice, Lord Hewart. This committee reported in 1932 and gave the system its qualified approval, subject to certain safeguards such as a right of appeal to the courts. The system has the great advantage of cheapness, and is free from the somewhat ponderous procedure which the law courts have inherited from the jury system. After all, if the law courts are not able to adapt themselves to meet some of the needs that have arisen in recent times, our constitution would only be doing what it has done many times before if it created new tribunals that could meet them.

The Crown derives its powers from two sources—first, the prerogative, and secondly, legislation. The powers derived from the prerogative are those which are given to the Crown by the common law, and it very often happens that one power is derived from both sources, for legislation may have confirmed what the common law had already given. It is impossible to compile a list of the prerogative powers. They are rarely relied on today, since ministers prefer to obtain parliamentary sanction for their proposed acts rather than to rely on their prerogative rights; but one great constitutional writer has pointed out that the Crown could, if it chose, disband the army and navy; sell all battleships and stores; make every citizen, male or female, a peer; dismiss most of the civil servants; and empty all the prisons by conferring free pardons.

Fortunately, it may be thought, it does not often choose to do any of these acts, but disputes still do arise, and it is for the courts in the last resort to say whether the Crown is or is not entitled to do any act by virtue of its prerogative. In 1856 the Crown tried unsuccessfully to create peers for life, but was unable to do so until it acquired statutory authority twenty years later. More recently, during the First Great War, the power of the Crown to impose taxes by right of the prerogative was denied. The Food Controller, being empowered by statute as a servant of the Crown to issue licences to control the supply of milk, made it a condition of the grant of a licence that the licensee should pay twopence for every gallon of milk purchased. The Courts held this to be illegal, since it amounted to the imposition of a tax without the consent of Parliament, which was beyond the power of the Crown by virtue of its prerogative.

Departments of State. It will be readily seen that at the present time, when Parliament is so much under the control of the ministers of the Crown, it is easier for the Crown to obtain statutory authority for the acts it wishes to do than to rely upon its prerogative rights, which may be ill-defined. Thus it is that all the principal acts of government are carried on under the authority of an Act of Parliament, and it is under this authority that the great government departments, such as the Treasury, and the various ministries, carry out their work. These departments of state are too numerous to be noticed here in detail. Their staffs of permanent officials are Civil Servants, and continue to function independently of any changes in the government. At the head of each department is a minister of the Crown, who is a member of one of the Houses of Parliament, and who holds office until he resigns, is dismissed, or moved to some other appointment, or the ministry as a whole resigns. Whether or not he is in the cabinet will largely depend on the department of which he is head. These ministers are assisted and, if necessary, represented by other non-permanent officials known by names differing according to the departments to which they belong. The Treasury is by far the most important department, for to it belongs the duty of controlling the expenditure of public money.

Of the Civil Service itself, little can here be said. Its chief characteristic, perhaps, is the principle that its members must take no part in politics. In view of the fact that they must serve under governments of all parties, the reason and good sense of this rule are obvious. The Trade Disputes and Trade Union Act of 1927 went so far as to forbid associations of Civil Servants to affiliate to the Trades Union Congress.

LESSON NINE

Methods of Trial Yesterday and Today

The use of a jury to decide questions of fact in both civil and criminal cases is one of the distinctive features of English jurisprudence; and trial by jury, in imitation of the English model, has spread to almost every country in the world. It cannot be claimed that the system has been an unqualified success everywhere, for in some countries it has seemed foreign to the natural instincts of the people, and even in England it has in recent years suffered a great decline in prestige.

The earliest traces of trial by jury are to be found at a period not long after the Norman conquest. We have seen elsewhere that the King popularized his own courts of justice as against the local courts by providing in his courts the privilege of trial by jury, which was considered more beneficial than the methods of trial prevailing in the local courts. The subject is itself of such great interest that some space may well be devoted to the more primitive methods of trial which the jury gradually superseded. The three best known were trial by compurgation, trial by ordeal, and trial by wager of battle.

In trial by compurgation the accused person first swore a solemn oath on some holy relics that he was innocent of the crime of which he was charged. He then produced twelve compurgators, who swore by the Lord that ' the oath is clean and unperjured which the man hath sworn,' and the prisoner automatically went free. It should be noted that these compurgators were in no sense witnesses to fact; they knew nothing of the facts of the crime; they were merely witnesses as to the character of the prisoner who alleged their belief in his innocence. A system of this kind would hold out little hope to a prisoner who was unpopular, or who was a stranger in the district, or of bad character; and where the number of ' oath-helpers ' could not be made up the oath was said to ' burst ' and the prisoner had to endeavour to establish his innocence by an appeal to the Almighty, Who in both the trial by ordeal and the trial by wager of battle was considered to prove the guilt or innocence of the accused.

Trial by Ordeal. Trial by ordeal is more ancient than Christianity; it is found in the Old Testament and among the Greeks. In this country it took various forms. First, there was the ordeal of cold water. In this, the water was first enjoined to cast forth the accused if he were guilty, but to allow him to sink if he were innocent, and he was then thrown into a pool or river. One might imagine that his death was provided for in any event! This belief in the efficacy of water survived until a very late age in the practice of testing witches by throwing them into a pond. In the ordeal by hot water, the accused had to thrust his hand into a pot of boiling water and pick out a stone. His hand was at once bandaged, and after three days the bandages were removed. Then if the wounds had healed, he was innocent; if not, he was guilty. There was a similar ordeal with red-hot metal, which had to be carried a distance of nine feet in the bare hand. It should be remembered that all the preparations for these ordeals were in the hands of the Church, and it may well be imagined that if the priests were inclined to favour the accused, the water might not be boiling nor the iron red-hot, and the ordeal thus was not so severe as it appeared to the spectators.

In the wager of battle the accused challenged his accuser to single combat. This applied to civil cases as well as to criminal charges. In civil cases the unsuccessful party had to pay a fine, and in criminal accusations he who did not resist until the end of the day was promptly hanged. Wager of battle was always unpopular, and soon fell into disuse. It was strangely revived in 1818, when a man charged with the murder of a girl pleaded not guilty and declared himself ready to defend the plea with his body against his accuser, the brother of the victim. The challenge was not accepted, and wager of battle was finally abolished in 1819.

Rise of the Jury System. All these methods of trial—if they can be so described—made no attempt to ascertain according to any standard of probability whether the facts of the case proved the guilt of the accused or not, and it may be readily imagined that, although they survived for some time, they could make no effective stand against the method of trial by jury provided by the king's courts. The modern jury consists entirely of persons who have no knowledge of the facts of the case, but who decide it on the evidence called before them either orally by witnesses or by the production of documents. This was not, however, the early conception of the duties of a jury. They were expected to have some knowledge of the facts, and no evidence was called to assist them in their decision.

In criminal cases, it was the duty of the jury to present for trial to the king's justices, who came to the county, all persons suspected of crime, and they were expected to support their presentment of their own knowledge or at least information. If the information was found to be derived from 'tavern gossip' or from a person to whose word no credit could be given, the suspected person was discharged, but in other cases he must be tried. This jury corresponded to the more recent grand jury, abolished in 1933 except in the case of indictments under certain Acts of Parliament. The finding of the presenting jury did not conclude the matter, for the suspect was then required to stand his trial, which he might elect to do by ordeal or one of the other methods mentioned above, or he might choose to 'put himself upon his country'—i.e. be tried by a jury.

Defects of Jury Trial. This trial was, however, not upon the evidence, for no evidence could be called, but again upon the knowledge of the 'petty jury,' which, in effect, meant that a prisoner of bad character was always convicted. In early times the 'trying' jury might consist of the same persons as the 'presenting' jury; but later a new jury was empanelled for the trial, and the prisoner was entitled to object to any member of the jury, on the ground, for example, that he was an enemy. Even when it became customary for the jury to decide upon evidence called before them, the evidence for long was that of the prosecution only, and not until 1702 was the prisoner allowed to call witnesses. He was not allowed to give evidence himself until 1898. The assistance of counsel in his defence was not available until 1836.

Thus the trial by jury was by no means the ideal instrument for ascertaining the truth that it has sometimes been represented to be. It is perhaps not surprising therefore that a prisoner was not bound to accept trial in this method and, indeed, could not be tried by jury unless he 'put himself upon his country' by pleading not guilty. If he remained mute he was, however, subjected to a strange process, called 'peine forte et dure,' to induce him to plead. Under this he was laid flat on the ground and weights were heaped upon him until he either pleaded or was crushed to death. Many persons chose this barbarous death in preference to a trial, in many cases because conviction (which was an almost invariable consequence of trial) entailed the forfeiture of the criminal's property as well as his death, and a refusal to plead followed by death under the 'peine forte et dure' did at least save his dependants from destitution. This process was not abolished until 1772. The last recorded occasion when a prisoner suffered death in this way was at Cambridge in 1741.

Juries Decrease. Civil juries have had much the same history as the criminal jury. Today, with certain exceptions, all natural born subjects of the King, both men and women, are subject to jury service. At the same time, the use of juries is decreasing. During wartime the jury is practically abolished in civil cases because of shortage of man-power. In peacetime, since 1933, civil actions are tried by a judge alone unless the Court orders trial by jury, except certain actions—e.g. libel, slander, and breach of promise—which are still normally tried by a jury. Jury trials are also more protracted, and therefore more expensive, than trials before a judge alone. Sometimes also a jury gives its verdict in the form of answers to a series of questions, and often when this happens the answers are apparently inconsistent, and a long hearing, with possible appeals to the Court of Appeal and House of Lords, is necessary to decide what the jury meant and what is the legal effect of its verdict.

Although all criminal cases at assizes or at the Old Bailey must still be tried by a petty jury, stipendiary magistrates and lay benches try cases and inflict serious punishment without the aid of a jury. During the Second Great War a fine of £100,000 (reduced to £50,000 on appeal) was imposed in a non-jury case.

The burden of unpaid service imposed upon the juror himself has also become very serious, as was well seen in the 'fire trial' at the Old Bailey in August, 1933, when the members of the jury were prevented from attending to their ordinary business for over thirty days. Even this, however, cannot compare with the trial of the Tichborne claimant in the eighteen seventies, which lasted 188 days.

LESSON TEN

A Note on Local Government

THERE is no very definite distinction in principle between the functions which are performed by the central government and those which are under the control of local government. The matter is rather one of convenience, and a branch of government is placed in the hands of the local authority, rather than in those of the central authority, usually because the local authority, being on the spot, is better able to acquaint itself with the facts relating to that branch of government, and to see that such control as it may consider necessary is properly exercised. Apart from expediency, the only principle which operates is that it is more in keeping with democratic tendencies to leave as many matters as possible in the hands of the local authorities. Even this principle is today more apparent than real in its operation, for the control which is exercised by local authorities in such matters as education and health is always subject to the supervision of the appropriate government departments.

In the early history of this country we find that the power of the local authorities is much greater than that of the central government, and, indeed, this is true of all early governments. Throughout history we find empires arising which are unable to outlive their creator, but on his death are split up into smaller units. This was the fate, to take only two celebrated examples, of the empires of Alexander the Great and of Charlemagne.

Early Local Government. In this country the most important and also the most difficult task of the early Norman kings was to build up a central government capable of controlling the unruly feudal barons. The local government of the time consisted of these barons, who administered the laws in their own courts and who kept peace within their territories by the simple method of brooking no rivals. The chief task of the king was to see that the laws that were administered were the laws of the land, and not the rules made by the individual barons, and that the military power was exercised by them as his servants and in his name. We have already seen how he achieved his object, so far as the control of the administration of law was concerned, by means of the itinerant judges and the jury system; but he had to wait almost until the breakdown of the feudal system before he acquired full control of the military power. It is not until we come to the time of the Tudors that we see the first beginnings of a local government with the characteristics now familiar to us. By this time, on the one hand, the power of the feudal barons had been completely broken, and, on the other, the dispersion of the monastic orders and houses had made itself felt in local affairs by throwing on their own resources the poor of the land, hitherto aided by the Church.

Poor Law Authorities. Thus it was that the first development of local government was by the creation of poor law authorities, each parish being made responsible for its own poor. From this time local government has extended, until today nearly all the public services, such as health and education, are administered at least in part by a local authority. A more recent development has been the increasing control over these services exercised by government departments, due to the fact that these services are not now maintained by the local rates only, but are largely subsidized from the national Exchequer. Two of the most important government departments which may thus be said to be at the head of our local government are the Ministry of Health and Board of Education. The local authorities whose activities are supervised by government departments are the parish council, the urban and rural district councils, borough councils, and the councils of counties and county boroughs. Every rural parish has a parish meeting and, if the population is 300 or over, a parish council. The parish is now of little importance in local government. It administers such parochial charities as are not ecclesiastical; it controls the stopping up or diversion of highways, and its consent is required for the adoption of certain acts: e.g. Lighting and Watching acts and Burial acts.

Rural and urban district councils and non-county boroughs comprise what are known as county districts. Both the rural and urban district councils are elected by the local government electors (who are fewer than those entitled to vote in parliamentary elections, since to obtain the local government franchise one must be, generally speaking, an *occupier* of premises within the district, or the wife of an occupier), and their duties are very similar. They are responsible for a variety of matters such as certain public health services and the housing of the workers. Urban district councils are responsible for repair of local roads and rural district councils may have that responsibility delegated to them. Boroughs have councils consisting of mayor, aldermen, and councillors. Non-county boroughs have much the same powers as rural and urban district councils, but county boroughs perform nearly all the local government functions within their area, including, e.g. police and education.

Powers of County Councils. The county council is the result of the latest trend of local government, which is towards local centralization, and now enjoys many powers previously exercised by smaller authorities. County councils were brought into existence by the Local Government Act, 1888, and since that time their powers have grown to such an extent that they completely overshadow all other local authorities, with the exception of the county boroughs, which are in effect counties in miniature. Outside the county boroughs county councils exercise a general supervision over the public health throughout the county, and may report to the Ministry of Health if they think the provisions of the Public Health Acts are not being observed. They control education in the county and are responsible for the main roads other than the trunk roads, which were taken over by the Ministry of Transport in 1937, and for the registration and licensing of motor-cars. Since 1929 they have also taken over from the boards of guardians the administration of the poor law. They have, further, a general power of acting when any other local authority neglects to carry out its duties.

Just as the finance of the central government is derived from taxes, so the local authorities rely upon the local rates, assisted now in many cases by grants from the Exchequer. Since 1925 one general rate levied by the rural and urban district councils and county and non-county boroughs has replaced the several rates for separate purposes formerly levied by various authorities. The county councils meet their expenses by precepts on the authorities within their jurisdiction, instead of levying a rate themselves. All local authorities have unlimited powers of borrowing, but may exercise their powers only with the consent of the Ministry of Health. Their accounts are subject to audit by government auditors.

The chief instrument used to effect the increased area of local administration was the Local Government Act, 1929, which enlarged the powers of the county councils, and gave them the duty of dividing among the other local authorities the contributions made by the Exchequer to local funds.

LESSON 11

The British Commonwealth

It is not within the scope of a Course on British constitutional law to consider the merits or demerits of the association of nations known as the British Commonwealth, the name which is now tending to be used as an alternative to or in preference for British Empire. The building-up of the Empire, its adaptation to changing circumstances, and, more important still, the holding together of its component parts through the strain of two world wars, despite the friction inseparable from wide diversities of race and interest, are, however, achievements of such outstanding magnitude that the constitutional methods by which they were brought about are well worth the closest study.

One is accustomed to think of our present Empire as dating from the days of Drake and Queen Elizabeth; but the Empire as we know it today really dates from the second half of the 18th century. In the American War of Independence of 1776–83 we lost a very important part of the Empire we then held. But what must, at the time, have seemed a disaster was in fact turned to good purpose, for it taught Britain that the Empire could be held together only on the principle that the control of the mother country must gradually be relaxed as her colonies grew to maturity, and that the ultimate aim must be the granting of full self-government to all units of the Empire large, strong, and united enough to warrant self-governing status.

The Statute of Westminster, 1931, and decisions at Imperial Conferences between the two world wars, mark the final achievement of this object in the case of the Dominions of Australia, Canada, New Zealand,

and South Africa. (The grant of Dominion status to Eire is anomalous, as the history of Eire is of course very different from that of the other Dominions. Newfoundland, also a Dominion, temporarily lost its constitution in 1933.) As is so often the case with legal enactments, however, the Statute of Westminster gave recognition to certain rules or conventions which had in practice been followed at least since the First Great War. The Government of India Act, 1935, is a step towards self-government in India.

Colonial Law. In early colonial days any idea of full self-government was unknown. Colonists who went as ' settlers ' to an uninhabited or uncivilized country took English law with them, and in many respects enjoyed the same position as when in this country. Queen Elizabeth's first patent to Sir Walter Raleigh guaranteed to English subjects accompanying him ' a continuance of the enjoyment of all the rights which her subjects enjoyed at home.' One of these rights was of course that laws should be made only by Parliament and not by the Crown, and the Crown could not therefore make laws for its subjects in such colonies any more than it could have made laws for them when they were in England.

As, however, new laws would be required to meet the needs of the colony and as distance and ignorance of local conditions—not to mention indifference—made the Parliament in this country unsuited for the making of these new laws, it was usual for the Crown to establish a legislature in the colony to enable it to control local matters; for although the Crown could not make laws, it could grant to the colonists a right to set up a legislature of their own, usually corresponding roughly with Parliament in this country. Very often this was done in the charter granted to the colonists when they set out. In more recent times Parliament granted the legislature. Most of the American colonies were originally ' settled ' colonies of this type, and Australia is a later example of the same type of colony.

Many of our colonies were not, however, formed by settlers in uncivilized countries but were conquered or taken over—' ceded ' —as the result of a successful war against the country by whom they had been previously colonized. These colonies usually had already their own laws and a legal system, and these they retained, until the Crown made new laws for them, as it had power to do, for these colonists were not ' settlers.' Later a legislature was usually set up in these colonies also, either by the Crown or by Parliament. South Africa and Quebec are the principal examples of colonies of this type: The basis of common law in the former is still the Roman-Dutch law brought out by the Boer settlers from Holland, and French law is still the basis of the law of Quebec.

When it is remembered that, in more recent times at least, it has also been the practice to preserve the legal effect of native customs so far as possible, it will be readily understood why there are so many different systems of law in the Empire and why the Judicial Committee of the Privy Council, which hears appeals from the members of the imperial family, has so wide and varied a jurisdiction.

Colonial Legislatures. It must not be assumed that a legislature granted to a colony could make such laws as it pleased. First of all, the grant of a legislature did not necessarily mean that the members were elected by the colonists under some system of franchise, though in settled colonies any constitution granted by the Crown involved representative government, i.e. was approximately on the same lines as the British Parliament, one body wholly or partly elected corresponding to the House of Commons, another nominated corresponding to the House of Lords, with a governor representing the Crown.

In course of time, however, many colonies which had enjoyed representative government of this kind lost the right to it for various reasons, until those which are now Dominions were almost the only ones retaining the right. In conquered and ceded colonies, moreover, the Crown could always grant any form of constitution it pleased. Further, Parliament when it granted the legislature was not controlled by any rules. The Crown continued to exercise effective control wherever it could nominate a majority of the legislative body.

Next, the consent of the Crown was necessary to legislation just as in England. This consent was given (or refused) either by the Crown itself or by some governor appointed by the Crown and, except until recently in the case of the Dominions, was by no means a mere formality. Again, Parliament could make any laws for the colony that it pleased in spite of the colonial legislature. Not only could it make laws for the colony, but under the Colonial Laws Validity Act, 1865, no colonial legislature could in general make any law which was repugnant to the provisions of any Act of Parliament applying to the Colony.

There should also be noted the right of the King in Council to hear appeals from his courts in any part of the Empire. This right is now exercised by the Judicial Committee of the Privy Council.

On the whole question too, the power of finance should be remembered. A colony which could 'pay its way' was naturally much more independent than one which had to rely on subsidies granted by the British Parliament. Newfoundland, Britain's oldest colony, had to give up its constitution in 1933 owing to financial difficulties which compelled it to ask for aid from the mother country.

Until 1931 the legal position substantially as stated above applied to all colonies, and it still applies to all except the Dominions and India. It should at once be made clear that strong conventions had grown up in many cases long before that date limiting the exercise of these powers, at any rate in the case of what became of the Dominions.

Constitutions of the Dominions. As it was never the practice to apply one model form of constitution to all colonies, and as many colonies have long enjoyed the power of altering their constitutions, we find the widest differences prevailing. The stronger and more important the colony, the greater the independence it was able to achieve. The highest form of self-government was responsible government, that is to say, where the colonial government was responsible to its own legislature—just as the government in this country is responsible to Parliament—instead of being responsible to the Colonial Office in this country. Long before the Statute of Westminster in 1931 gave legal recognition to this position, it had been an established fact in the case of what we now call the Dominions—most clearly shown by their admission to the Versailles peace conference, the grant to Australia, New Zealand, and South Africa of mandates over former enemy colonies, and their membership of the League of Nations. The most comprehensive definition of their position was that given by Lord Balfour's committee set up by the Imperial Conference in 1926.

> 'They are equal in status, in no way subordinate one to another in any respect of their domestic or external affairs, though united by a common allegiance to the Crown, and freely associated as members of the British Commonwealth of Nations.'

It was this definition to which legal effect was given in 1931.

The Statute of Westminster provided, first, that Parliament in this country shall not legislate for any of the Dominions except at its own request, and, second, that any law made by a Dominion would be valid notwithstanding that it was repugnant to imperial legislation. By the first provision Parliament lost all legislative power over the Dominions, and by the second each Dominion acquired full power of legislation. Each of the Dominions still has a governor-general who represents the Crown, but he is appointed by the King on the nomination of the Dominion. It is recognized, moreover, that he acts on the advice of the government in the Dominion, just as the Crown in this country acts on the advice of the government here. There is a convention that the Crown no longer vetoes any Dominion legislation, and by another convention each Dominion has the power to refuse to allow appeals from its own courts to the Judicial Committee.

The first matter of real importance on which it was necessary to secure joint action with the Dominions was the abdication of King Edward VIII in 1936. The Abdication Act states that it is passed on the request and with the consent of Canada and with the assent of Australia, New Zealand, and the Union of South Africa. Some of the Dominions, however, passed special legislation of their own to give effect to the abdication.

In external affairs the Dominions are also independent. They send diplomatic representatives to foreign powers and decide for themselves whether to remain neutral in any war in which Great Britain is engaged.

Both at the time of Munich in 1938, and before war was declared on Germany by Great Britain in 1939, close touch was maintained with the governments of the Dominions. Great Britain, however, had no power to declare war on their behalf: that could be done only by their own Parliaments; Canada, Australia, New Zealand, and South Africa decided to declare war on the side of the mother country. Eire decided to remain neutral, as she had a right to do. Her decision, however, deprived Great Britain of the use of the naval bases in south-west Ireland, which had been handed back to Eire under an agreement made in 1938. This imposed a great handicap on Great Britain in the war against the German U-boats.

The only remaining legal link binding the Dominions to Great Britain is their common allegiance to the Crown. Eire, which has rejected all allegiance to the Crown in internal affairs, nevertheless still as a matter of convenience recognizes the Crown for certain international purposes. However, the strength of this legal link is doubtful. The true link is that voluntary and free association of the members of the Commonwealth referred to by Lord Balfour. Sentiment is deeply involved in this association; but in addition to sentiment there is the recognition of the vast strength which such an association gives.

LESSON 12

The Constitutions of the Empire

The constitutions of the Dominions are modelled closely on that of Great Britain. Each has a legislature consisting of a Governor-General, corresponding to the King, and two Houses, one usually nominated and the other elected, corresponding to the House of Lords and the House of Commons. The Governor-General is appointed by the Crown, but selected by the Dominion government. He is also in theory at the head of the executive and there is a cabinet with a prime minister. This cabinet advises the Governor-General just as the cabinet in England advises the Crown, and he is by convention of the constitution bound to act on its advice. The Dominion cabinet is responsible to the Dominion legislature.

Newfoundland. Newfoundland is our oldest colony, having been discovered in 1497. It had a constitution separate from the Dominion of Canada. As a Dominion, it attended imperial conferences and is included in the Statute of Westminster, but in 1933 its government found itself unable to pay the interest charges on its public debt, and accordingly an address was presented to the King asking the Imperial Parliament to pass legislation suspending the constitution until Newfoundland should become self-supporting again, This was done by the Newfoundland Act, 1933. The British government assumed general responsibility for the finances of the island, and a special commission was created, presided over by the Governor, with full legislative and executive authority.

New Zealand. New Zealand has been a separate colony for over a hundred years. There is a governor-general and executive council, a Legislative Council the members of which are nominated on the advice of the prime minister of New Zealand, and an elected House of Representatives.

Eire. In an effort to put an end to the disturbed state from which Ireland had suffered for centuries—a state that had been bitterly accentuated since the Easter Rising of 1916—an Act was passed in 1922 creating the Irish Free State and conferring on the Free State Dominion status. Six counties in the province of Ulster took advantage of a clause in the Act allowing them to opt out of the arrangement, and they form Northern Ireland, which, though a part of the United Kingdom, returning 13 members to the House of Commons at Westminster, has also its own Parliament (Senate and House of Commons) at Stormont, Belfast.

The Irish Free State (officially known since 1937 as Eire) is one of the Dominions mentioned in the Statute of Westminster. Its position as a Dominion is somewhat anomalous, for Ireland was never a colony in the same way as Canada or Australia, and had been incorporated as part of the United Kingdom since 1801. Its constitution as established in 1922 was modelled on that of Canada. There was a representative of the Crown appointed in the same way as the Governor-General of Canada, and a Parliament consisting of a Senate and a lower house, the Dail. The members of Parliament took the oath of allegiance ‘ to the constitution of the Irish Free State as by law established ’ and swore that they ‘ would be faithful to His Majesty King George V.’ The oath of allegiance was abolished in 1933, and the office of governor-general in 1936; and in 1937 a plebiscite established a new constitution by which the national territory is declared to be the whole island of Ireland. There is a President, House of Representatives (the Dail), who are elected, and a Senate (partly elected and partly nominated). Bills passed by both houses require the President’s consent. All legal connexion with the British Crown was severed, except for some international purposes.

Canada. Canada is a federation: that is, there is a central government with power in certain matters over the whole country, and in addition each province has its own government, subordinate to the central authority but sovereign in prescribed matters within its own territory. The federation was created under the British North America Act, 1867. There are a Governor-General and Privy Council; Parliament consists of a nominated Senate and an elected House of Commons. The central legislature has power to legislate on all matters not exclusively assigned to the provincial legislatures. Each of the provinces has a lieutenant-governor, and its own elected legislative assembly.

Australia. The Commonwealth of Australia was formed in 1901 by the federation under the Australian Commonwealth Act of the six original states of the continent. There are a Governor-General and a Council, and the legislature consists of the governor-general, an elected Senate, and an elected House of Representatives. The various states also have legislatures, and these (like the states of the U.S.A., but unlike the Canadian provinces) can make laws on any matters not specifically assigned to the central legislature.

Union of South Africa. The Union of South Africa was established in 1910 when four colonies, the Cape of Good Hope, Natal, Transvaal, and the Orange Free State, were given a much modified type of federal government. The Parliament consists of the Governor-General, a mainly elected Senate, and an elected House of Assembly. There are provincial councils with limited powers which can be overruled by the central government.

Colonies. Before the Statute of Westminster a colony was defined as being ‘ any part of His Majesty's dominions exclusive of the British Isles and British India ’; but under the Statute of Westminster the expression ‘ colony ’ does not include a Dominion or part of a Dominion. The Statute of Westminster does not apply to colonies. Colonies are administered under the Colonial Office. Parliament retains full power of legislating, and legislation passed by the colony must not be repugnant to any act of Parliament intended to apply to them. The types of constitution are very varied.

Crown Colonies possess no responsible government, and the executive power is in the hands of the Crown, exercised by a governor, under the control of the Colonial Secretary. In some colonies the Crown has full control of legislation, which is exercised by means of an official majority in the legislature, the governor being entitled to nominate more than half of the representatives, and only the remainder being elected. In others, the power of the Crown to legislate is exercised directly, there being no legislative body in the colony and all laws being made by the Crown by order in council. In yet other colonies the two methods are combined. An example of the first colonial class is British Honduras, of the second Gibraltar; while the third, by far the largest, includes Mauritius. There is another small class in which there is a nominated Legislative Council and an elected House of Assembly, both of which participate in legislation, so that full control is not in the hands of the Crown. Only three colonies fall into this class—namely, the Bahamas, Barbados and Bermuda. The assent of the governor is necessary to all legislation made in the colony, and this is not a mere formality. Moreover, any such legislation can in most colonies be later disallowed by the Crown.

Protectorates. Protectorates are not technically British possessions. The degree of control exercised varies enormously from one Protectorate to another.

Mandated Territories. After the First Great War the colonies lost by Germany and Turkey were granted on League of Nations mandates to members of the successful allied and associated powers. Great Britain received, among others, a mandate in Palestine. Mandates were also granted to the Dominions, Samoa being granted to New Zealand, New Guinea to Australia, and South-West Africa to the Union of South Africa. The mandates are of three different types depending on the degree of civilization in the country. The League of Nations exercised a general supervision over all these mandated territories.

India. British India, that is, the parts of India directly under the control of this country, is at present controlled in part by the government at home and in part by the government in India. The former consists of the India Office in London, at the head of which is the Secretary of State for India. The latter is controlled by the Governor-General (the Viceroy) with the assistance of an executive council—like himself, appointed by the Crown—and under his charge is the whole of the military and administrative forces. Legislation is in the hands of a Council of State and a Legislative Assembly, both with elected majorities. The Viceroy's assent is required to all legislation, and even after it has been given, the Crown may still impose a veto; but in matters other than the control of the army and its finance the policy of the government is to interfere as little as possible with the local legislature.

Besides British India, there are some 500 states in India ruled by native rulers, and varying enormously in importance. They are not British territory, but the Crown exercises considerable control over them, usually by virtue of powers granted by treaty. Their rulers meet in the Chamber of Princes, which has, however, no executive or legislative powers.

For many years British statesmen and the British public were feeling their way towards the grant of some form of self-government to India—a concession demanded more and more urgently by the Indian people. In 1917 Mr. Edward Montagu, then Secretary for India, declared that the policy of this country for India was 'the greatest possible development of self-governing institutions with a view to the progressive realization of responsible government in India as an integral part of the British Empire.' The Government of India Act (1919) was the first step in this development. It gave elective assemblies in some of the provinces responsibility for certain defined aspects of government.

A royal commission appointed by the British Government, and round-table conferences in London, between representatives of the native princes, the British Government, and leaders of Indian opinion in British India, resulted in the Government of India Act 1935, which provided for the ultimate creation of a federation giving, subject to certain safeguards, responsible government to the whole of British India and the Indian native states. The Act gave considerable immediate extension of responsible government in the provinces; but the putting into effect of the further provisions contemplated by the Act was interrupted by the outbreak of the Second Great War. As a result of proposals made in 1945 by Lord Wavell, Viceroy of India, a conference of Hindu and Moslem leaders was held at Simla to consider increase of Indian responsibility on the Executive Council. Unfortunately it failed partly owing to difficulties raised by the Moslem League over the representation of the Moslem community on the Council.

BOOK LIST

General. 'English Law,' J. L. Brierly (Oxford Pamphlets on Home Affairs); 'Elements of English Law,' W. M. Geldart (H.U.L.); 'Common Sense in Law,' P. Vinogradoff (H.U.L.); 'In Quest of Justice,' C. Mullins (Murray); 'British Justice,' Maurice Amos (Longmans); 'The Machinery of Justice in England,' R. M. Jackson (C.U.P.); 'English Justice,' 'Solicitor' (Routledge; also Pelican); 'The Outlook for International Law,' J. L. Brierly (Oxford, Clarendon Press); 'The Modern English Prison,' J. Fox (Routledge); 'First Report of Committee on Legal Aid for the Poor' (H.M. Stationery Office Cmd. 1926/2638); 'Final Report of Committee on Legal Aid for the Poor' (H.M. Stationery Office Cmd. 1928/3016); 'Report of the Committee on Legal Aid and Legal Advice in England and Wales' (H.M. Stationery Office Cmd. 1945/6641); 'Report of the Committee on Persistent Offenders' (H.M. Stationery Office Cmd. 1932/4090); 'Crime and Psychology,' C. Mullins (Methuen); 'Penal Reform in England,' J. W. C. Turner (P. S. King & Son).

Constitutional Law. 'How Britain is Governed,' R. B. McCallum (Oxford Pamphlets on Home Affairs); 'British Political Institutions,' A. Browning (Craig and Wilson); 'Local Government,' J. P. R. Maud (H.U.L.); 'Parliament,' C. P. Ilbert (H.U.L.); 'The British Commonwealth,' J. L. Morrison (Craig and Wilson); 'Constitutional Law,' A. B. Keith (Stevens & Sons); 'The Constitution under Strain,' A. B. Keith (Stevens & Sons); 'The English Constitution,' Walter Bagehot (Oxford U.P.); 'The Law of the Constitution,' A. V. Dicey (Macmillan); 'The English Constitution, 'Maurice Amos (Longmans); 'The American Constitution,' Maurice Amos (Longmans); 'Law and Orders,' C. K. Allen (Stevens & Sons).

RUSSIAN

THIS Course represents a new approach to the study of Russian—one which simplifies the first trying days and makes the learner realize that the language is not nearly so formidable as he had imagined. It is, in effect, a first approximation to a ' Basic Russian.' If this Course is carefully followed, the student should be able to read normal Russian in about six months, and, as he progresses, he will find the language flexible, rich and altogether delightful.

Courses on other modern languages in this work are FRENCH (*Vol. I*), GERMAN (*Vol. II*), ITALIAN (*Vol. III*), SPANISH *and* PORTUGUESE (*Vol. IV*). *The Course on* PHILOLOGY *in Vol. II is complementary to the study of all languages.*

9 LESSONS

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BY special arrangement with the Orthological Institute of Cambridge, and in collaboration with its editor, Mr. Charles Duff, each of the six Courses in French, German, Italian, Spanish, Portuguese and Russian has been expressly prepared for PRACTICAL KNOWLEDGE FOR ALL *from the respective handbooks and readers issued in pocket volumes for the Institute by Messrs. Nelson & Sons, Edinburgh and London.* *The copyright of these Courses is strictly reserved by the Orthological Institute of Cambridge.*

LESSON ONE

Alphabet and Pronunciation

More people in Britain begin to learn Russian and, after a very few months or weeks abandon the study, than is the case with any other language. One can hardly fail to notice how many people are heard saying, ' I should like to learn Russian, but it is far too difficult for me ' or ' That Russian alphabet puts me off—I could never learn it.'

All this is both a pity and somewhat unrelated to the truth, though partly justified because of the traditional approach to this delightful, remarkable and by no means formidable language. We have been accustomed to an entirely wrong approach to Russian—wrong from the outset of study, wrong from the very moment the alphabet is approached. The complete Russian alphabet, including the letters abolished in 1918, consists of 36 letters. As all books printed before 1918 use the full alphabet, if pre-revolution literature is to be read the 36 letters must be known. Then, while still in the first days of study, if the learner is informed that, in addition to the *ordinary* alphabet, there are *italic* and *script* alphabets to be learnt, in which many letters differ from those of the ordinary alphabet, he sees himself confronted with the task of learning dozens of strange letters before he can get down to the language itself. No wonder so many people soon give up in despair!

One Normal Alphabet. In this Course, we avoid this entirely unnecessary obstacle by an approach which is completely logical and consistent, one which simplifies those first trying days of study to a surprising degree—so much so that hundreds of learners who have used it have been known to master the Russian alphabet in an hour or so. The approach is this: we learn *one* normal alphabet, that which is used for 90 per cent of all printed matter. For a beginning, we avoid both italics and script alphabets—they can be learnt at the end of the Course (*see* p. 551), when the student knows something of the language; and then they are learnt at one sitting.

All through the Course, when anything has to be written by the learner, he just *prints it out in block letters*, thus

МОСКВА = *Moscow*

This method serves a double purpose. First, the learner quickly becomes familiar with the alphabet in common use; second, writing a word out in block letters impresses it on his memory in the form in which it will nearly always be met. When a learner has mastered the values of the letters and their pronunciation, he does not have to write

МОСКВА (pronounced *mosskva*)

many times in block letters before the whole word is impressed on his visual memory so strongly that he takes it all in every time he meets it in print. And so on with every new word he meets. This is a wonderful short-cut to learning, and the learner soon realizes that Russian is not nearly so terrifying as he had imagined.

The Cyrillic Alphabet. Let us now examine the Russian alphabet. It is called the Cyrillic alphabet after its inventor St. Cyril, a learned monk of the 9th century, who made it up from the Greek and Latin alphabets—with the addition of some characters for sounds not in those languages. The full alphabet to-day (*see* p. 500) consists of 36 letters. Of these—

5 are pre-1918 and need not be learnt immediately
11 are the same as ours
8 resemble our letters but have different values
12 differ from ours entirely, and include letters which we have not.

So it is seen that there are 16 letters—those which are the same, and the pre-1918 letters—or half the alphabet which causes no trouble at all.

What the beginner must first learn are the 8 letters resembling ours but having different values; and the 12 entirely different letters. Here are the 8:

Russian		*English equivalent*
В	=	V
Н	=	N
Р	=	R
С	=	S
Х	=	*ch* guttural (Scotch lo*ch*)
bi	=	*i*, a sound peculiar to Russian
b	=	marks a soft, or palatilized consonant (dealt with later)
ə	=	*e*, like French *é*, pronounced *ay*

the last three are printed thus in Russian

Ы ы,
Ь ь,
Э э,

Why learn these first? Because, really, they are liable to be a little confusing at first, and it is best to clear away any possibility of confusion before we come to the 12 entirely different letters. Here they are:

	Russian	*English equivalent*
(1)	Г г,	*g* in *get* or *give*, never like *g* in gem
(2)	Ж ж,	*s* in plea*s*ure, or French *j*
(3)	И и,	*e* like *ee* in f*ee*t
(4)	Л л,	
(5)	П п,	*p*
(6)	Ф ф,	*f*
(7)	Ц ц,	*ts* in bi*ts*
(8)	Ч ч,	*ch* in *church*
(9)	Ш ш,	*sh* in *ship*
(10)	Щ щ,	*shch* in A*shch*urch
(11)	Ю ю,	*iu*, the *u* sound in m*u*te
(12)	Я я,	*ia*, the *ya* sound in *ya*m

Now, you can see why МОСКВА is pronounced *mosskva* and you know that the Russian СССР, the abbreviation for Union of Soviet Socialist Republics, is really SSSR in our letters, and that РЕСТОРАН when transliterated into our alphabet makes the word *restoran*, meaning restaurant. Here, you realize that, although the Russian word *looks* very strange to us—if we do not know the alphabet—when *spoken* it is very similar to our own. And, you may well say to yourself with some pleasure: 'Russian is not so difficult, after all!'

Take a piece of paper and print out these letters in simple block letters with their equivalents a few times. Then, you may for practice use the following Russian alphabet. Exercise your memory on it, until you know the equivalent English for every Russian letter.

РУССКИЙ АЛФАВИТ

а б в г д е ж з и й к
л м н о п р с т у ф х
ц ч ш щ ъ ы ь э ю я

You will see that the fifth letter from the left on the last line is one of those abolished in 1918. The Boyanus and Müller Russian-English Dictionary, a popular and useful modern dictionary printed and published by the State Publishing House in Moscow, has included it for reasons we shall state later. It is letter 28 of the full alphabet, given in page 500.

You need not wait until you think you know all these letters perfectly before proceeding to the 'Remarks on Pronunciation of Vowels' (p. 501). When you know them moderately, you may then tackle 'Basic Values of the Letters,' given in page 500.

You will very soon notice that the Cyrillic alphabet is admirably conceived for Russian; and economical. If you write out in our letters the phonetic equivalent of almost any Russian word, you will notice that it is longer and stranger than the Russian original. (Written and italics Russian letters are given in p. 551.)

Russian and Other Languages. Having made this simplified approach to Russian and, by this time, realized that it is not so formidable a language as you may have imagined, your confidence may be further strengthened by considering its difficulty compared with that of other languages. It is easier to pronounce than either French or Portuguese; and far easier to 'catch' in conversation. It is easier to construe than German—you may put words in almost any order in Russian and the grammar is not impaired. As for reaching a reading knowledge, this can be achieved with very little more effort than is necessary in Latin or Greek. There are European languages much more difficult: Finnish, Hungarian and Basque, for example, or even Welsh or Erse.

In the U.S.S.R. thousands of non-Russian speaking peoples learn it every year, some of them so well as to produce literature in it. While we make no pretence that it is an easy language—*no* language is easy—what we wish to impress on you is that, if this course is carefully studied, in six months you will be reading normal Russian. A speaking knowledge is a matter of practice, and for this a native speaker is desirable for the first lesson or so, until the pronunciation is mastered. There are only three sounds in Russian which need cause any difficulty.

This Course provides the essential raw material of the language. Learn all of it. **Learn ten new words from the vocabulary every day.** Keep a notebook. After a month, get a Reader—though not essential, it will help. The 'Basis and Essentials Russian Reader,' by A. M. Krougliakoff, or the 'First Russian Reader,' by Anna Semeonoff, can be recommended. Try to master one column and ten new words every day. At that rate you will make good progress.

Letters		Names in Russian	Equivalents in English letters and pronunciation	Examples
1	А, а	ah	a in father	Бáба—peasant woman
2	Б, б	bay	b in bit	
3	В, в	vay	v in vat	Вот—here
4	Г, г	gay	g in get, give	Губá—lip
5	Д, д	day	d in day, do	Да—yes
6	Е, е	yay	ye' in yet, ye'llow (ё accented is like yaw in *yawl*)	Дед-grandfather
7	Ж, ж	zhay	s in measure, z in azure. (Exactly like French j in *jardin*)	Женá—wife
8	З, з	zay	zz in buzz, s in rose	За—for
9	И, и	ee	ee in feel, i in machine	Или—or
10	Й, й	ee kratkoye	short, that is, like i in boil. '(kratkoye крáткое means '*short*') *Used only to follow another vowel*, forming a diphthong.	Толстóй—Tolstoi
11	І, і	ee s' tóchkoy	i in machine. (с тóчкой means *with a dot*)	Прі́ѣздъ—arrival (old spelling)
12	К, к	kah	k in kite	Как—how
13	Л, л	ell	a hard sound like ll in mill	Лáмпа—lamp
14	М, м	emm	m in man, mouse	Мáма—mama
15	Н, н	enn	n in not, night	Но—but
16	О, о	oh	o in not Often sounds like a short a	Он—he
17	П, п	pay	p in pit, pin	Пáпа—papa
18	Р, р	airr	r in road, but slightly thrilled	Рот-mouth
19	С, с	ess	s in some, soon. Never like s in rose	Сын—son
20	Т, т	tay	t in tin, tough	Там—there
21	У, у	ooh	o͞o in moon, u in rule	Тут—here
22	Ф, ф	eff	f in fit	Фут—foot
23	Х, х	hhah	h *strongly aspirated*. (Like Scotch ch in Loch, Irish lough; or German ch in *Dach*; exactly like Spanish *jota*)	Хорóший—good
24	Ц, ц	tsay	ts in bits, wits,	Царь—Tsar
25	Ч, ч	chay	ch in chain, china	Чай—tea
26	Ш, ш	shah	sh in ship, smash	Шерсть—wool
27	Щ, щ	shchah	*This is one sound*: like *sht* plus *ch* in *smasht-china* said quickly Or *shch* in Ashchurch. Practise these two English expressions	Щекá—cheek
28	Ъ, ъ	tvyordi znak	'hard' sign (твёрдый знак) which makes the preceding consonant *hard*	Шумъ—noise
29	Ы, ы	yerrwee	a sound peculiar to Russian, for which the nearest English equivalent is the short i in sin pronounced with the teeth clenched	Сын—son
30	Ь, ь	myahki znak	'soft' sign (мягкий знак) makes the preceding consonant *soft*, that is, as if a half-suppressed y sound came after it. maht'	Мать—mother
31	Ѣ ѣ	yaht	ye in ye't	Ѣ́сть—eat
32	Э, э	ay	ay in day, or e in fête	Этáж-stage storey
33	Ю, ю	yooh	u in useful, or you in yourself	Брю́ссель—Brussels
34	Я, я	yah	ya in yard, yam	Я́ма—pit
35	Ѳ, ѳ	feeta	f in fun, fight	rarely used
36	Ѵ, ѵ	eezhitsa	i in mint, flint. Only to be found in older books	

NEW ORTHOGRAPHY.

A new orthography was introduced in 1918, and with it were completely abolished the following: **ѣ, ѳ, і, ъ,**[1] **ѵ**. They are included in the complete alphabet above, because many books can only be found to exist in the old, full orthography. The new spelling (now used throughout the USSR) is the one used in the present book. Being simpler it is an advance on the old. In it we find that **е** takes the place of **ѣ**; **ф** takes the place of **ѳ**; **и** takes the place of **і**: while **ѵ** no longer exists. It is advisable to memorise the alphabet in the above order, as well as to master the equivalents. This will save time in looking up words in a dictionary. Master the thirty six letters, as they are all used in classical Russian literature.

REMARKS ON THE PRONUNCIATION OF VOWELS

Russian vowels are classified under the heads of ' hard ' and ' soft ', thus :

Hard			*Soft*		
а	pronounce	ah, in *father*.	**я**	pronunced	yah, in *yard*.
э	„	ay, in *day*.	**е**	„	ye, in *yet*.
ы	„	i, in *bit*.	**и**	„	ee, in *eel*.
о	„	o, in *not*.	**ё**	„	yo′, in *yoke*.
у	„	oo, in *moon*.	**ю**	„	you′, in *yourself*.

ь and **й** are called semi-vowels : the first is always found after a consonant, the second after another vowel.

The above are the simple values of the vowels, but note the following slight variations :

а, in an *accented* syllable is always *ah* :

англича́нин	Pr : angleechah'neen	an Englishman

а, in an unaccented syllable is a much shorter sound:

у́лица	Pr : oóleetsa	a street

э, has *invariably* the sound of ' a ' in *day* :

экза́мен	Pr : aykza'men	examination
э́тот	Pr : áytot	this

ы —close the teeth, utter the English words *bill, bits, pity*, and try to make the vowel sound *well down in the throat*. This should produce the Russsian **ы**

сын	Pr : sin	son

After lip consonants (**п, б, ф, в, м**) there is a slight w sound before it :

мы	Pr : mwee	we
вы	Pr : vwee	you
мы́ло	Pr : mweelo	soap

о *accented* or at the *end of words* is like English o in *note*, or a little shorter like o in *on*. *Unaccented* it is like English a in *mat* :

о́ба	Pr : ob'a	both
чу́до	Pr : choódo	wonder
она́	Pr : aná	she
доро́га	Pr : daroga	way, road

у is invariably pronounced like oo in *moon, spoon*

ду́рно	Pr : doorno	badly

я, *accented* or at the *end of words* like English ya in *yard* :

я́ма	Pr : yahma	pit, hole
А́нглия	Pr : ang'leeya	England

Otherwise **я** has a much shorter sound resembling ye' in *yet* :

де́вять	Pr : dye'vet	nine
язы́к	Pr : yezík	tongue, language

е at the *beginning* of a word or syllable, or when *accented*, is like ye' in *yet* :

есть	Pr : yesst'	is, he is
Сове́т	Pr : sovyét	advice, council
апте́ка	Pr apptye'ka	chemist's shop

ё like yo' in *yoke* (or *yaw*). The word **ещё** has both Russian e's.

ещё	Pr : yeshchaw'	still, yet, more, ' *encore* '

Otherwise Russian **е** is like English e in *bet* : or ye in *yet*.

ребёнок	Pr : rebbyon'ok	baby, infant

и invariably like i in *machine*, or ee in *meet* :

и	Pr : ee	and
и́ли	Pr · eelee	or
прие́зд	Pr : preeyezd'	arrival

й is used only after another vowel, to form a diphthong. Then it has an effect similar to i in *boil*, or y in *boy* :

мой	Pr : moy (or mo'ee)	my
си́ний	Pr : see'neey	blue
чёрный	Pr : chorn'weee	black

ю invariably like you in *yourself* (yoo) :

юг	Pr : yoog	South
ю́мор	Pr : yoômor	humour

THE HALF-VOWEL **ь** *(OR ' SOFT ' SIGN).*

ь has the sound of a half-uttered y, thereby ' softening ' the consonant which precedes it. In such English words as ' educate,' 'onion,' in which the *u* and the *o* have a short y-sound before them, we have an approximate equivalent. A similar sound in French is the *gn* in Boulogne, cigogne ; and in

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[1] For certain words **ъ** has been reintroduced—where a consonant before a soft vowel is to be pronounced distinctly. Example : **Объе́кт**, an object. In some works this will be found written : **Об'ект**, pronounced ob-yekt′. In the Boyanus & Muller Dictionary (Moscow 1936) **Объе́кт** is written with **ъ**.

Spanish ñ in Señor. But the 'softening' can occur after *every* Russian consonant (except г, к, х,) and in the middle or end of a word. When ь occurs at the end of a word it may cause the foreigner some trouble.

мать Pr : maty (almost *match*) } mother **дать** Pr : dat' to give

-**ва́ть** is a common termination of verbs. (Pr: vaht').

REMARKS ON CERTAIN CONSONANTS.

The equivalents given in the table of the alphabet have few exceptions. The following should be noted: **Кто** (who) is pronounced as if written **хто**; and **ч** before **т** is pronounced sh: **что** (what)—shto. Similarly **ж** before **к** is often sh: **ло́жка** (pr: losh'ka) a spoon; and **щ** before **н** like sh—**Помо́щница** (pomosh'neetsa), an assistant (f.).

GENITIVE ENDINGS—**ого** AND **его**

In genitive terminations the г takes the sound of English v. Thus: **его́** (his) is pronounced yev'ó.

моего́ (of my) mayevo' **ста́рого** (of the old) star'avo.

STRESS OR ACCENTUATION

In every Russian word of more than one syllable there is always a syllable *much* more heavily stressed than the rest. It is very regrettable from the foreigner's point of view that there are no practical rules to help him to discover this stressed syllable. *He must learn the pronunciation of each word as it occurs*, and to this end we have marked every stressed syllable with a graphic accent ('). Books for Russians do not have this accent. The student will have no difficulty in finding accented texts : and he should keep to them, and to an accented dictionary, until he has become thoroughly familiar with the language.

The importance of stressing heavily the accented syllable can hardly be exaggerated—all other syllables may be pronounced lightly, 'slid over,' providing the one with the stress is momentarily held.

GENERAL REMARKS ON PRONUNCIATION.

It should be clearly understood that the equivalents for pronunciation given above are, at best, makeshifts. Strictly, every letter or combination of letters in Russian represents a sound or sounds which have no *exact* equivalents in English. Good pronunciation can only be learnt from good native speakers, and they are not always easy to find. But if there is one European language for which a passable pronunciation can be learnt from a book, it is Russian ; which is, on the whole, a language in which 'one letter represents one sound.' The apparently formidable alphabet is, in fact, very well conceived to meet the phonetic requirements of the language. The student who persists will in a short time realize how great a *help*[1] is this elaborate alphabet ; especially if he has studied French, for example, in which orthography is of no help in so important a feature of the language as 'liaison,' or for silent letters and many other irregularities. The three most difficult Russian letters for the English speaker to pronounce are л (hard), ь (soft sign) and ы. Try to get somebody from Moscow to repeat them until you know them.

Here are some proper names in Russian characters, to assist in mastering the alphabet :

ЛО́НДОН, London. **МА́НЧЕСТР**, Manchester. **О́КСФОРД**, Oxford. **ЧЕ́ЛСИ**, Chelsea. **ЛОЙД ДЖОРДЖ**, Lloyd George. **РА́МЗЕЙ МАКДО́НАЛЬД**, Ramsay Macdonald. **ТРО́ЦКИЙ**, Trotzky. **ТОЛСТО́Й**, Tolstoy. **ЛЕ́НИН**, Lenin **БИ́ВЕРБРУК**, Beaverbrook. **ЧЕ́РЧИЛ**, Churchill. **КЕ́НЗИНГТОН**, Kensington. **ГЛА́СГО**, Glasgow.

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[1] Turn to any of the Russian words for which an English equivalent pronunciation is given, and it will be seen that the Russian original is the more concise.

LESSON TWO

Declension and Nouns

Russian is what grammarians call a synthetic language. By this they mean that it prefers to make compound and derivative words and to use endings (or inflexions) rather than depend upon a liberal use of particles as in English, for example. Nouns, adjectives and pronouns change their *endings* to denote different shades of meaning ; and this process is called *Declension*. Thus :

Бара́н, means a ram. **Бара́на**, „ of a ram.

Бара́ну, „ to a ram.

—and so on throughout six '*Cases*' in the singular and the same in plural. These cases are :—

1. *NOMINATIVE* :	names the *Subject* or initiator of action or speech, and answers the question *WHO?* (**КТО?**) or *WHAT?* (**ЧТО?**)
2. *GENITIVE*	Indicates the *Possessor* of something, and answers the question *WHOSE?* (**КОГО́?**)[1] or *OF WHAT?* (**ЧЕГО́?**)[2] The Genitive plural is used after the word **МНО́ГО**—*MANY*, and after some other adverbs (see p.520) **МНО́ГО ДЕТЕ́Й**—*many children* literally *many of children*.
3. *DATIVE* :	Indicates the *Recipient* of something, and answers the question *TO WHOM* (**КОМУ́ ?**) or *TO*

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[1] Pronounce KAVO.

[2] Pronounce CHEVÓ.

	WHAT? (**ЧЕМУ́?**). This is the Indirect Object of action or speech.
4. *ACCUSATIVE :*	indicates the Direct Object—the person or thing *immediately affected* by the action answering the question *WHOM?* (**КОГО́?**) or *WHAT?* (**ЧТО?**).
5. *INSTRUMENTAL:*	as its name implies denotes the instrument by which or with which the action is done, and answers the question *BY WHOM?* (**КЕМ?**), or *WITH WHAT?* (**ЧЕМ?**)
6. *LOCATIVE :*	usually indicates the locality in which an action is done, and answers the question *WHERE? WHEREABOUTS?* (**О КОМ?**—*ABOUT WHOM?* **О ЧЁМ?**-*ABOUT WHAT*) It is sometimes also called the Prepositional Case because it is always preceded by one of the prepositions—**О, ОБ,** *OF, ABOUT;* **ПО**—*AFTER;* **В, ВО**—*IN, INTO;* **ПРИ**—*AT, NEAR;* **НА**—*ON, UPON.* (See pages 520-1)

There is also a Vocative case but, except in a few ecclesiastical expletives, it is the same as the Nominative. **БÓЖЕ** ! Oh GOD !—This is a Vocative.

It is impossible to make progress in Russian until the simple uses of these cases are understood. The Declension of adjectives and pronouns being regular can be learnt fairly quickly. That of nouns is not so easy, as there are irregularities. Comfort may be found in the thought that it is by no means unusual for Russians to trip up on the inflexions of nouns. Constant repetition is necessary. What is given in the pages which follow is a bare minimum. The *Tables of Inflections* should be thoroughly known ; otherwise sense will not be made of even simple sentences.

NOUNS

" A Noun is a word used for naming some person or thing "—*Nesfield.*

ABSENCE OF WORDS FOR a *AND* the.

There are no words in Russian for the English definite and indefinite articles. Thus : **АВТОМОБИ́ЛЬ** may mean either *the* automobile or *an* automobile, according to context or what comes after. If it is desired to single out a special automobile, then some other word or words must be called in to make the meaning clear : *one, this, that, such and such* an automobile, *here* or *there,* etc.

GENDER.

Russian nouns are of one of three genders : masculine, feminine, neuter. But Russian genders do not coincide with the simple English usage of males, females and inanimate objects.

(1) MASCULINE ARE :	Nouns denoting males, whatever their endings. Nouns ending in a *hard* consonant or —**Й**. Nouns ending in —**Ь** and having their Genitive in —**Я**. Proper names ending in —**Ь**. Nouns ending in a hissing consonant: —**Ж**, —**Ч**, —**Ш**, —**Щ**.
(2) FEMININE ARE :	Nouns denoting females whatever their ending. Most nouns denoting *abstract* qualities. Nouns ending in —**А**, or—**Я**. Nouns ending in —**Ь** with Genitive in —**И**.
(3) NEUTER ARE :	Nouns ending in —**О**,—**Е**, or —**МЯ**,

	(1)	(2)	(3)
Thus:	*Masculine*	*Feminine*	*Neuter*
	Брат, brother	**Мать**, mother	**Сло́во**, word
	Дя́дя, uncle	**Кни́га**, book	**О́бщество**, company
	Слу́чай, occasion	**Ли́ния**, line	**Усло́вие**, condition
	День, day	**Речь**, speech	**И́мя**, name
	Кора́бль, ship	**Вещь**, thing	
		Честь, honour	

Hence the ending of a Russian noun deserves close scrutiny—declension also being dependent upon gender.

There are certain endings for male beings which have corresponding endings for their females just as in English we have baron, baron-ESS, patron, patron-ESS.

Thus in Russian:

MALE ENDING		*CORRESPONDING FEMALE ENDING*
—ИК **—ЕЦ**		**—ИЦА**
—ТЕЛЬ		**—ТЕЛЬНИЦА**
Й **Ь**	may take one or other of	**—ИНЯ** **—ЫНЯ** **—ЬЯ** **—ИХА**
Various		**—КА**, proceeded by another letter or syllable.

So :

Племя́нник	nephew	**Племя́нница**	niece
Прия́тель	male friend	**Прия́тельница**	female friend

Гость	male guest	Гостья	female guest

And so forth. These endings are useful, as they provide the key to hundreds of words.

DECLENSIONS OF NOUNS.

The beginner should take this subject gently. Let him read the immediately following pages through a few times in order to grasp the general principles of the Russian Declensions and, for the moment, concentrate upon the TABLE on page 505. He should, however, return later and memorize the " Models " given below.

It is convenient to classify Russian nouns into those of masculine, feminine and neuter gender and into '*Hard*' and '*Soft*,' (see Page 501) in accordance with the ending of the Nominative case.

A " Hard " noun is one which ends in a consonant (with "—ъ" in the old spelling), or a "hard" vowel (see page 501); a 'soft' noun is one which ends in one of the " soft " vowels or the soft sign (—ь). This distinction should be kept clearly in mind, as it is of great importance: *the "soft" declensions will be found to follow the same general rules and inflexions as the hard excepting that their vowels remain soft throughout. Hence, the beginner is advised to concentrate his attention upon the ' hard ' models first.*

§ 1. MODELS FOR MASCULINE NOUNS

	Nom.	Gen.	Dat.	Acc.	Inst.	Loc.
Hard endings Singular:	(ъ)	—а	—у	like Nom. or Gen.	—ом	—е
Hard endings Plural:	—ы	—ов	—ам	like Nom. or Gen.	—ами	—ах

Thus:	*Singular*	*English Equivalent*
Nominative	Пароход	a, or, the steamer.
Genitive	Пароход—а	of the steamer.
Dative	Пароход—у	to the steamer.
Accusative	Пароход	steamer (recipient of action).[1]
Instrumental	Пароход—ом	by (means of) the steamer.
Locative	О пароход—е	about the steamer (always with a preposition).
	Plural	
Nominative	Пароход—ы	the steamers.
Genitive	Пароход—ов	of the steamers.
Dative ;	Пароход—ам	to the steamers.
Accusative	Пароход—ы	steamers (object).[1]
Instrumental	Пароход—ами	by the steamers
Locative	О пароход—ах	about the steamers.

Now consider the 'soft' endings of masculine nouns and compare them with the ' hard ' already given :

	Nom.	Gen.	Dat.	Acc.	Inst.	Loc.
Singular:	—ь(—й)	—я	—ю	—ь (я), й	—ем (ём)	—е
Plural:	—и	—ев (—ей)	—ям	—и(—ев—ей)	—ями	—ях

	Singular	
Nominative	Случа—й	the occasion, opportunity.
Genitive	Случа—я	
Dative	Случа—ю	
Accusative	Случа—й	(in animate beings is like the *Genitive.*)
Instrumental	Случа—ем	
Locative	О случа—е	
	Plural	
Nominative	Случа—и	occasions, opportunities.
Genitive	Случа—ев	
Dative	Случа—ям	
Accusative	Случа—и	(in animates like the *Gen.*).
Instrumental	Случа—ями	
Locative	О случа—ях	

There is a difference in pronounciation between ай (in singular) and —аи (plural)—, ай being a diphthong and the *ahee* said quickly (as in Kaiser), while in the plural form the *ah* and ee sounds are distinct the ee coming out more clearly.

An important group of masculine nouns end in the hissing consonants ж, ч, ш, щ and they have their nominative plural in —и instead of —ы and genitive plural in —ей instead of —ов.

Furthermore, if the accent is not on the *last* syllable in the nominative singular they take an —е instead of —о in the instrumental singular.

Singular:	Товарищ, —а, —у, —а, —ем, —е.	comrade
Plural:	Товарищи, —ей, —ам, —ей, —ами, —ах.	

§ 2. MODELS FOR FEMININE NOUNS.

	Nom.	Gen.	Dat.	Acc.	Inst.	Loc.
Hard endings Singular:	—а	—ы	—е	—у	—ою	—е
Hard endings Plural:	—ы	(ъ)	—ам	—ы(ъ)[1]	—ами	—ах

Thus:

	Singular	
Nominative	Комнат—а	a room.
Genitive	Комнат—ы	of a room, &c.
Dative	Комнат—е	
Accusative	Комнат—у	
Instrumental	Комнат—ою	
Locative	О комнат—е	

And in the plural: Комнаты, комнат, комнатам, —ы, —ами, —ах (See footnote, page 505).

Similarly the ' soft ' feminine nouns:—

	Nom.	Gen.	Dat.	Acc.	Inst.	Loc.
Soft endings Singular:	—я	—и	—е	—ю	—ею (ёю)	—е
Soft endings Plural:	—и	—ь	—ям	—и (ь)[1]	—ями	—ях

Thus:

Неделя (week), Недели, —е, —ю, —ею. —е.

Plural: Недели, etc.

Feminine nouns ending in —ия or —ья are similarly declined, but take –и in the Dative and Locative, –ей in the Instrumental singular and –й in the Genitive plural

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[1] In animates it is like the Genitive.

	Singular	
Nominative	**Па́ртия**	the party
Dative	**Па́ртии**	
Instrumental	**Па́ртией**	
Locative	**О па́ртии**	
	Plural	
Genitive	**Па́ртий**	

Feminine nouns ending –ь are declined as follows: **Часть**, a part.

Singular· **Ча́сть, Ча́сти, Ча́сти, Ча́сть, Ча́стью, О ча́сти.**

Plural: **Ча́сти, Часте́й, Частя́м, Ча́сти, Частя́ми, О частя́х.**

The two very common soft feminine nouns for *mother* and *daughter* (**мать, дочь**) are declined:

Singular· **Мать, Ма́тери, Ма́тери, Мать, Ма́терью, О ма́тери.**

Plural: **Ма́тери, –е́й, –я́м, –е́й, –я́ми, –я́х.**

Дочь, До́чери, etc.

§ 3. MODELS FOR NEUTER NOUNS.

	Nom.	Gen.	Dat.	Acc.	Inst.	Loc.
Hard endings Singular·	–о	–а	–у	–о	–ом	–е
Hard endings [1]Plural:	–а	(–ъ)	–ам	–а	–ами	–ах

Thus:

О́бщество (society, association) –а, –у, –о, –ом, –е.

Plural: **О́бщества, О́бществ, –а́м, –а, –а́ми, –а́х.**

	Nom.	Gen.	Dat.	Acc.	Inst.	Loc.
Soft endings [2]Singular:	–е (ё)	–я	–ю	–е (ё)	–ем (ём)	–е
Soft endings Plural:	–я	–ей	–ям	–я	–ями	–ях

Thus:

По́ле (field) –я, –ю, –е, –ем, –е.

Plural· **Поля́, –е́й, –я́м, –я́, –я́ми, –я́х.**

When –ь comes before the soft –е of a nominative neuter, then declension is as follows:

Singular **Воскресе́нье** (Sunday) –ья, –ью, –ье, –ьем, –е.

Plural: **Воскресе́нья, –ий, –ьям, –ья, –ьями, –ьях.**

Having read these ' Models ' over a few times until the general principles are appreciated, now study carefully the Table on this page which gives a ' Birds-eye ' view of the declension of nouns. From this the following general rules may be evolved :

GENITIVE and DATIVE SINGULAR of Masculines and Neuters are *the same*.

DATIVE, INSTRUMENTAL AND LOCATIVE PLURALS are *the same* for all nouns.

MASCULINE and NEUTER SINGULARS are almost the same.

FEMININE and NEUTER PLURALS are almost the same.

LOCATIVE SINGULAR always ends in –е excepting in a few feminine nouns which take –и.

Note that most feminine nouns ending –жа, –ча, –ша, –ща, and –ья preceded by another consonant take –ей in the genitive plural instead of (–ъ) and –ь.

THE MOST FREQUENTLY RECURRING NOUNS IN RUSSIAN ARE :

1. Those ending in consonant (hard) and with hard ending, –е and –о.
2. Those ending –а and –я (feminine).
3. Those ending –е (neuter, abstract nouns.)

and their declension is, on the whole, regular.

It has already been noted that *accentuation* (or stress) is of vital importance, In many nouns this changes with inflexion, thus

Nominative	**Ключ**	a key
Genitive	**Ключа́**	

(accent shifted to last syllable).

When the accent shifts from nominative to genitive in this manner, it, *remains so* throughout the remainder of its inflexions. Thus:—**Ключи́**—keys (Nom. Pl) etc. There are no safe rules to guide the learner in this (grammarians have, in fact, evolved a number, but there are hosts of exceptions to them), so the best course is to learn the genitive, and to be doubly sure the plural of each noun as it is met.

BIRD'S EYE VIEW OF THE DECLENSION OF NOUNS.

Case and Number	MASCULINE NOUNS			FEMININE NOUNS			NEUTER NOUNS	
	Hard	Soft (after consonant)	Soft (after vowel)	Hard	Soft -Я	Soft -Ь	Hard	Soft
Singular								
Nom.	–(Ъ)	–Ь	–Й	–А	–Я	–Ь	–О	–Е, –Ё
Gen.	–А	–Я	–Я	–Ы	–И	–И	–А	–Я
Dat.	–У	–Ю	–Ю	–Е	–Е	–И	–У	–Ю
Acc.	–(Ъ) –А	–Ь –Я	–Й –Я	–У	–Ю	–Ь	–О	–Е, –Ё
Inst.	–ОМ	–ЁМ	–ЕМ	–ОЙ –ОЮ	–ЕЙ –ЕЮ	–ЬЮ	–ОМ	-ЕМ,-ЁМ
Loc.	–Е	–Е	–Е	–Е	–Е	–И	–Е	–Е
Plural								
Nom.	–Ы(–И)	–И	–И	–Ы (–И)	–И	–И	–А	–Я
Gen.	–ОВ(ЕЙ)	–ЕЙ	–ЕВ	(-Ъ)	–Ь	–ЕЙ	(–Ъ)	–ЕЙ
Dat.	–АМ	–ЯМ	–ЯМ	–АМ	–ЯМ	–ЯМ	–АМ	–ЯМ
Acc.	–Ы(–И) –ОВ	–И –ЕЙ	–И –ЕВ	–Ы(-И) (–Ъ)	–И –Ь	–И –ЕЙ	–А	–Я
Inst.	–АМИ	–ЯМИ	–ЯМИ	-АМИ	–ЯМИ	-ЯМИ	–АМИ	–ЯМИ
Loc.	–АХ	–ЯХ	–ЯХ	-АХ	–ЯХ	–ЯХ	–АХ	-ЯХ

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[1] –ъ, –ь, for animates. (*When –а, is preceded by г. к, х guttural, or hissing ж, ч, ш, щ then ы in genitive sing. and nom. and acc. pl. change to –и In hissing consonants ою of Inst. becomes –ею or ей.)

[1] –о preceded by guttural or hissing sound then Nom and Acc. Pl. is –и instead of –а.

[2] After hissing sounds –я and –ю become –а and –у.

Golden Rule

In memorising the nouns in the vocabulary in Lesson 8 always learn the genitive singular and the nominative plural in addition to the nominative singular.

By this means nearly all the irregularities of nouns may be absorbed without the necessity for learning a mass of rules and exceptions—which would tend to confusion and delays.

Characteristic Masculine endings in the Nominative are: Consonant (**—ъ**) and **—й**.

Characteristic Feminine endings in the Nominative are: Consonant **—а** and **—я**.

Characteristic Neuter endings in the Nominative are: Consonant **—о** and **—е**.

SUMMARY RULE FOR DECLENSION:

If a noun has (in the Nominative Case) any of the above Nominative Endings, then its declension follows the inflexions in the Table, as shewn in the Model Declensions.

NOTES ON IRREGULARITIES (FOR REFERENCE).

Masculine Nouns: Besides the regular singular Genitive (**—а**, **—я**) there is a Gen. Sing. in **у**, **ю** which is employed in many frequently recurring expressions, especially with reference to a portion or a part of something :—

Стака́н ча́ю—a glass of tea; **Кусо́к са́хару**—a piece of sugar; **Мёду**—some honey; **Сы́ру**—some cheese; **Табаку́**—some tobacco, etc.

There is also a Locative in —ý instead of the regular form **—е**: **В году́**—in the year; **На мосту́**—on the bridge; **На полу́**—on the floor; **Во рту́**—in the mouth; **В углу́**—in the corner; **В саду́**—in the garden; etc. It is only used with **на**—on; and **в**, **во**—in.

Many masculines have their plural in **—á** (**—я́**) instead of the regular **—ы** (**—и**), the only distinction between Nom. Pl. and Gen. Sing. being the accentuation, which shifts to the plural á and remains through all plural inflections:—

		Plural
Го́род	town, city	**Городá**, **—óв**, **—áм**, etc.
Дом	home, house	**Домá**
Го́лос	voice	**Голосá**
Учи́тель	teacher	**Учителя́**
О́стров	island	**Островá**
Снег	snow	**Снегá**

Foreign nouns ending **—ор**, **—ер**, generally denoting a profession or calling, follow this usage and take "**á**" in the plural: **До́ктор**—doctor, **Доктора́**; **Дире́ктор**, **—á**; **Ку́чер**—cab driver (from' German *Kutscher*), **Кучерá**, etc.

Certain masculines ending in hard (**—ъ**) or **ь** have Nom. plural in **—ья** and G. Pl. in **ьев**: **Стул**—chair, **Сту́лья**, **Сту́льев**; **Лист**—leaf, **Ли́стья**, **Ли́стьев**.

NOTE, the common words. **Сын**—son, Pl. **Сыновья́**, G. Pl. **Сынове́й**; **Друг**—friend, Pl. **Друзья́**, G. **Друзе́й**; **Муж**,—husband, Pl **Мужья́**, G. **Муже́й**.

The ending **—анин**, indicating 'an inhabitant of,' omits **—ин** in the plural and takes **е** in the nominative: **Англича́нин**—an inhabitant of **А́нглия** (England), i.e., Englishman: **Англича́не**—Englishmen, etc.

The ending **—ёнок** signifying small animate beings is lost in the plural and replaced by **я́та**: **Ребёнок**—little child, Pl. **Ребя́та**. **Телёнок**—calf, Pl. **Теля́та**.

Two Plurals, each with different meaning: **Лист**—leaf; **Листы́**—leaves of paper; **Ли́стья**—leaves of a tree; **Хлеб**—bread and also grain (wheat, corn); **Хлéбы**—loaves of bread, **Хлебá**—grains (of cereals); **Цвет**—colour and flower; **Цветы́**—flowers, **Цветá**—colours.

NOTE. **Господи́н**—Master, boss, Sir. Plural—**Господá**, G. Pl. **Госпо́д**

Feminine Nouns. Feminines in **—ья** lose **—ь** in the Genitive Plural, and this is formed in **—ей**:

Семья́—family. **Семе́й**—(G. Pl.)
Статья́—article. **Стате́й**—(G. Pl.)

Neuter Nouns. Certain Neuters ending **—о** take **—ья** in the N. Pl. and **—ьев** in G. Pl.

Перó—pen	N. Pl: **Пéрья**	G. Pl: **Пéрьев**
Дéрево—tree	N. Pl: **Дерéвья**	G. Pl: **Дерéвьев**

Similarly certain Neuters in **—ье** form the plural nominative in **—ья**, G. Pl: **—ьев** : **Плàтье**, garment, clothing—**Плáтья**, G, Pl: **ьев**.

NOTE. **О́ко**—eye and **У́хо**—ear :— Plurals—**О́чи**, **У́ши**.

Я́блоко—apple	Pl : **Я́блоки**	G : **Я́блок**
О́блако—cloud	Pl : **Облакá**	G : **Облакóв**
Нéбо—sky	Pl : **Небесá**	G : **Небéс**
Дитя́—child	Gen. Sing. **Дитя́ти**	Pl : **Дéти**
Чу́до—wonder, miracle	Pl : **Чудесá**.	

Miscellaneous Irregularities: The word **Человéк**—man uses the word **Лю́ди**—(*people*) for the plural (N. **Лю́ди**, **—éй**, **—ям**, **—éй**, **—ьми́**, **—ях**.) Another word—**Муж** has **Мужи́** for men, but **Мужья́** for husbands.

The letters **—е** and **—о** behave in a disconcerting manner, sometimes being inserted, sometimes being dropped for the sake of euphony. Thus **Отéц**—father, **Отцá** (Gen.), **Отцу́** (Dat.), Plural : **Отцы́**. **День**—day, **Дня**, **Дню**, **Дни**. This applies to all genders. **Земля́**—land. Gen. Pl: **Земéль** (Fem.). **Сéрдце**—heart. Gen. Pl: **Сердéц** (neuter). This 'fleeting' irregularity is best learnt by observation, and committed to memory.

(A) The student is advised, on a first perusal of this Course, to memorize only pages 502–505 and the table on page 505 of the declension of nouns.

(B) The aim is to master general principles and essentials first.

(C) The nominative and genitive singular and the nominative plural are the essential parts of the Russian noun.

LESSON THREE

Adjectives, Numbers and Pronouns

An adjective is a word used to describe the quality of a noun.

In Russian as in English an adjective may precede the noun, as when we say 'The *new* house.' Or it may follow it, as when we say "The house is *new*." In Russian when the adjective precedes the noun (as in "The new house") and qualifies it as its "attribute" it has a *long form*. If it follows (as in "The house is new") and is a part of a "predicate" with a verb expressed or omitted it has a *short form*.

The English adjective is invariable, but the Russian adjective is declined, and has the same six cases as the noun. Furthermore, it agrees in gender, number and in case with the noun which it qualifies.

Thus the Russian word for 'new' is **нов** and for "house" is **дом**. A new house is—**нóвый дом**. "The house is new" is—**дом нов**.[1]

Adjectives have a hard and a soft declension, in accordance with whether they end in 'hard' or 'soft' vowels.[2]

Long Declension 'hard' **НÓВЫ—Й** *new*

Singular.

	Masc.	*Fem.*	*Neut.*
Nom.	**Нóвый**	**Нóвая**	**Нóвое**
Gen.	**Нóвого**	**Нóвой**	**Нóвого**
Dat.	**Нóвому**	**Нóвой**	**Нóвому**
Acc.	**Нóвый** or **–ого**	**Нóвую**	**Нóвое**
Inst.	**Нóвым**	**Нóвою**	**Нóвым**
Prep.	**О Нóвом**	**Нóвой**	**Нóвом**

Plural

All three genders.

Nom	**Нóвые**
Gen.	**Нóвых**
Dat.	**Нóвым**
Acc.	**Нóвые** or **–ых***
Inst.	**Нóвыми**
Prep.	**О Нóвых**

Note that the plural is the same for all three genders.

All "hard" declensions of adjectives follow the model of **Нóвый**.

Long Declension 'soft.'

The 'soft' declension of adjectives is exactly similar to the 'hard' except that a soft vowel replaces the hard in the *endings*. Example **Сúний**, blue

Singular

	Masc.	*Fem.*	*Neut.*
N.	**Сúний**	**–яя**	**–ее**
G.	**–его**	**–ей**	**–его**
D.	**–ему**	**–ей**	**–ему**
A.	**–ий** or **–его**	**–юю**	**–ее**
I.	**–им**	**–ей (ею)**	**–им**
P.	**–ем**	**–ей**	**–ем**

Plural.

All three genders

N.	**Сúние**
G.	**Сúних**
D.	**Сúним**
A.	**Сúние (or сúних)**
I.	**Сúними**
P.	**Сúних**

NOTE. All masculine adjectives nominative long form end in **–ый**, **–ий** or **–óй**.

Feminines end in **–ая** or **–яя**

Neuters " " **–ое** or **–ее**

When an adjective follows the noun, as in the example 'The house is new' as already stated, the shortened form is used. This short form is found by dropping the long endings : **–ый**, **–ий** or **–óй** in the masculine, the last **я** in the feminine and the last **е** in the neuter, and adding **ь** to the root in soft masculine.

Thus : 'Hard' long form **нóвый**, **–ая**, **–ое** becomes **нов**, **нóва**, **нóво**.

'Soft' long form **сúний**, **–яя**, **–ее** becomes **синь**, **сúня**, **сúне**.

Where the root of an adjective ends in a consonant preceded by another consonant or **ь** or **й** the short masculine form is formed by adding **о** (or **е** before **л**, **м**, **н**), when euphony demands it, between the two consonants in the first case and by **ь** and **й** being changed into **е** in two other cases :

Thus :

корóткий	(short)	**корóтОк**
огрóмный	(huge)	**огрóмЕн**
свéтлый	(bright, clear)	**свéтЕл**
больнóй	(ill)	**бóлЕн**
бýйный	(violent)	**бýЕн**

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[1] In Russian the word 'is' is omitted—in fact, the present tense of the verb 'to be' is almost obsolete. See page 516.

[2] Refer back to page 501.
'Remarks on the pronunciation of vowels' and also to the 'Table of Declension of Nouns' on page 505. It will be found later that the adjective endings are very similar to those of pronouns on page 511.

* The Accusative of the Masculine Singular, and of all three Genders in the plural, is the same as the Nominative with inanimate things and the Genitive with animate things. In adjectives as in nouns **ы** after hissing or guttural is replaced by **–и**.

but note **чи́стый** (clean) —**чист**, which sounds well without **о**.

Apart from these changes, *the short form is invariable throughout all cases.*

The plural of the short form is—**ы** (*hard*) *or* **и** (*soft*) *for all three genders.*

TABLE OF DECLENSION OF ADJECTIVES.

LONG FORM SINGULAR						
	Masc.		*Fem.*		*Neut*	
Cases	*Hard*	*Soft*	*Hard*	*Soft*	*Hard*	*Soft*
N.	ый (ой)	ий	ая	яя	ое	ее
G.	ого	его	ой	ей	ого	его
D.	ому	ему	ой	ей	ому	ему
A.	Like the *N* or *G*		ую	юю	ое	ее
I.	ым	им	ою (ой)	ею (ей)	ым	им
P.	ом	ем	ой	ей	ом	ем

PLURAL

ALL THREE GENDERS		
Cases	*hard*	*soft*
N.	ые	ие
G.	ых	их
D.	ым	им
A.	Like the Nominative or Genitive	
I.	ыми	ими
P.	ых	их

SHORT FORM

SINGULAR					
Masc.		*Fem.*		*Neutr.*	
Hard	*Soft*	*Hard*	*Soft*	*Hard*	*Soft*
—	ь	а	я	о	е

PLURAL

ALL THREE GENDERS	
Hard	*Soft*
ы	и

RULE. ALL ADJECTIVES ARE DECLINED IN ACCORDANCE WITH THIS TABLE.

COMPARISON OF ADJECTIVES.

The Comparative of the long (or attributive) forms of adjectives is formed by putting the word **Бо́лее** (more) before the positive, thus **У́мный**—clever, intelligent

Бо́лее у́мный—more clever, more intelligent.

Thus the Russian word **Бо́лее** placed before an adjective corresponds to the common English ending *-er* for the comparative, as, for example, in stronger, taller, bigger, smaller, etc

There are two Russian words for THAN—**ЧЕМ** and **НЕ́ЖЕЛИ**. Used with **Бо́лее** and an attributive (long) adjective in the nominative to follow, they express *more. . . . . than, -er. . . . than*

Бо́лее у́мный челове́к чем Ива́н, more clever man than Ivan (John).

Бо́лее си́льное живо́тное не́жели лев, a stronger animal than the lion.

LESS is expressed in Russian by **МЕ́НЕЕ**. Thus, **Ме́нее высо́кий**—less high, tall. **Ме́нее у́мная**—less clever (femin.) **Ме́нее глубо́кое**—less deep (neuter).

In the case of the short (or predicative) form of adjective, the comparative is formed by changing the ending **ый**, **ий**, or **ой** into **ее** or **ей** (for all three genders).

The word thus formed is never declined.

Си́льный — strong
Сильне́е, –е́й — stronger

Than—**Чем**, **Не́жели**, following a short form of adjective can be omitted while the noun or pronoun after the ' than ' is then put in the Genitive :

Ко́шка хитре́е соба́ки (gen.),—The cat (is) craftier (than) the dog. Or, **Ко́шка хитре́е чем соба́ка** (nom.).

Either form is correct.

EQUALITY is expressed by—**ТАК ЖЕ** (as) . . . . **КАК** (as).

Он так же умён как она,—He is *as* clever *as* she.

IRREGULAR COMPARATIVE FORMS.

The following is a list of frequently recurring adjectives of which the comparative is irregular.

Positive	*Comparative*		
	Predicative	*Attributive*	
Бли́зкий	Бли́же		near -er
Бога́тый	Бога́че		rich -er
Большо́й	Бо́льше	Бо́льший	big -er
Высо́кий	Вы́ше	Вы́сший	high -er
Гла́дкий	Гла́же		smooth -er
Гро́мкий	Гро́мче		loud -er
Далёкий	Да́льше		distant, more distant
Дешёвый	Деше́вле		cheap -er
Дорого́й	Доро́же		dear-er, expensive, more-
Коро́ткий	Коро́че		short -er [-ier
Лёгкий	Ле́гче		light -er, easy,
Ма́ленький	Ме́ньше	Ме́ньший	small -er
Молодо́й	Мо̀ло́же		young -er
Ни́зкий	Ни́же		low -er, vile -r
Плохо́й	Ху́же	Ху́дший	bad, worse
Просто́й	Про́ще		simple -r
Ре́дкий	Ре́же		scarce -r
Ста́рый	Ста́рше		old -er
Твёрдый	Тве́рже		hard -er

Ти́хий	**Ти́ше**		gentle -r
То́лстый	**То́лще**		stout, thick -er
То́нкий	**То́ньше**		thin -er
Хоро́ший	**Лу́чше**	**Лу́чший**	good, better
Худо́й*	**Ху́же**	**Ху́дший**	bad, worse
Ча́стый	**Ча́ще**		frequent
Чи́стый	**Чи́ще**		pure, chaste
Широ́кий	**Ши́ре**		wide

The SUPERLATIVE in Russian is formed in three ways :—

(1) By adding the word **Всех**, meaning 'of all' to the comparative of a short form when this is used.

(2) By putting **Са́мый, –ая, –ое**, literally meaning 'the same,' but here meaning 'the most, utmost,' before the long form of an adjective when it is used.

(3) By adding **–е́йший, –е́йшая, –е́йшее** to the root of the adjective

Thus:

(1) **Э́тот дом лу́чше всех**—This house (is) the best of all. **Та у́лица длинне́е всех**—That street (is) the longest of all.

(2) **Са́мое си́льное госуда́рство**—The strongest state.

(3) **Богате́йший челове́к в ми́ре**—The richest man in the world.

IRREGULAR SUPERLATIVES.

Positive	*Comparative*	*Superlative*	
Бли́зкий	**Бли́же**	**Ближа́йший**	near
Вели́кий	**Бо́льше**	**Велича́йший**	great
Ста́рый	**Ста́рше**	**Старе́йший**	old
Ти́хий	**Ти́ше**	**Тиша́йший**	slow, gentle
Широ́кий	**Ши́ре**	**Широча́йший**	wide

NOTE : All the irregular comparatives and superlatives must. be known, as they are of frequent recurrence.

NUMBERS

CARDINALS	*ORDINALS*
1 **оди́н, одна́, одно́**	**пе́рвыи, пе́рвая, пе́рвое**—first
2 **два, две** (f.)	**второ́й, а́я, о́е**—second
3 **три**	**тре́тий, тья, тье**—third
4 **четы́ре**	**четвёртый, ая, ое**—fourth
5 **пять**	**пя́тый, ая, ое**—fifth
6 **шесть**	**шесто́й, а́я, о́е**—sixth
7 **семь**	**седьмо́й, а́я, о́е**—seventh
8 **во́семь**	**восьмо́й, а́я, о́е**—eighth
9 **де́вять**	**девя́тый, ая, ое**—ninth
10 **де́сять**	**деся́тый, ая, ое**—tenth
11 **оди́ннадцать**	**оди́ннадцатый, ая, ое**—11th
12 **двена́дцать**	**двена́дцатый, ая, ое**—12th
13 **трина́дцать**	**трина́дцатый, ая, ое**—13th
14 **четы́рнадцать**	**четы́рнадцатый, ая, ое**—14th
15 **пятна́дцать**	**пятна́дцатый, ая, ое**—15th
16 **шестна́дцать**	**шестна́дцатый, ая, ое**—16th
17 **семна́дцать**	**семна́дцатый, ая, ое**—17th
18 **восемна́дцать**	**восемна́дцатый, ая, ое**—18th
19 **девятна́дцать**	**девятна́дцатый, ая, ое**—19th
20 **два́дцать**	**двадца́тый, ая, ое**—20th
21 **два́дцать оди́н**	**два́дцать пе́рвый, ая, ое**—21st
22 **два́дцать два**	**два́дцать второ́й, а́я, о́е**—22nd
30 **три́дцать**	**тридца́тый, ая, ое**—30th
40 **со́рок**	**сороково́й, а́я, о́е**—40th
50 **пятьдеся́т**	**пятидеся́тый, ая, ое**—50th
60 **шестьдеся́т**	**шестидеся́тый, ая, ое**—60th
70 **се́мьдесят**	**семидеся́тый, ая. ое**—70th
80 **во́семьдесят**	**восьмидеся́тый, ая, ое**—80th
90 **девяно́сто**	**девяно́стый, ая, ое**—90th
100 **сто**	**со́тый, ая, ое**—hundreth
200 **две́сти**	**двухсо́тый, ая, ое**—200th
300 **три́ста**	**трехсо́тый, ая, ое**—300th
400 **четы́реста**	**четырехсо́тый, ая, ое**—400th
500 **пятьсо́т**	**пятисо́тый, ая, ое**—500th
600 **шестьсо́т**	**шестисо́тый, ая, ое**—600th
700 **семьсо́т**	**семисо́тый, ая, ое**—700th
800 **восемьсо́т**	**восьмисо́тый, ая, ое**—800th
900 **девятьсо́т**	**девятисо́тый, ая, ое**—900th
1000 **ты́сяча**	**ты́сячный, ая, ое**—thousandth
2000 **две ты́сячи**	**двухты́сячный, ая, ое**—two thousandth
10,000 **де́сять ты́сяч**	**десятиты́сячный, ая, ое**—ten thousandth
1,000,000 **миллио́н**	**миллио́нный, ая, ое**—millionth
1,000,000,000,000 **биллио́н**	**биллио́нный, ая, ое**—billionth

To the ordinals belong also the following numbers which are declined as *adjectives:*

друго́й –а́я, –о́е—the other; **после́дний –яя, –ее**—the last; **еди́ный**—alone; **двоя́кий**—twofold; **двойно́й**—double.

DECLENSION OF NUMBERS.

Cardinal numbers ending in '**ь**' as **пять, де́сять**, etc., are declined like feminine nouns in '**ь**': **пять, пяти́, пяти́, пять, пятью́, (о) пяти́.**

Со́рок, сто, ты́сяча, миллио́н—are declined like nouns of corresponding terminations; e.g. **ты́сяча, и, е, у, ью, (о) ты́сяче, ты́сячи, ты́сяч**, etc., but **со́рок и сто** are now used only in singular nom., and accus., **со́рок, сто**, and.

* Also means 'thin' of animate things, in which case the comparative is **худе́е**.

in gen., **сорокá, ста**, while in plural **сорок** is hardly used at all except in gen., **сорокóв** in a popular expression **сóрок сорокóв** (40×40) when referring to the number of churches in Moscow, and **сто** is used in gen. plural —**сот**, dat. —**стам**, inst. —**стáми**, and prep. —**(о) стах.**

Одúн, два, три, четы́ре, óба (both) have a special declension.

	Singular			*Plural*
	Masc.	*Fem.*	*Neut.*	
N.	**одúн**	**однá**	**однó**	**однú**
G.	**одногó**	**однóй**	**одногó**	**однúх**
D.	**одномý**	**однóй**	**одномý**	**однúм**
A.	Like N. or G.	**однý**	**однó**	Like N. or G.
I.	**однúм**	**однóю**	**однúм**	**однúми**
P.	**(об) однóм**	**однóй**	**однóм**	**однúх**

Plural

	Masc.&Neut.	Fem.	for the three Genders.		Masc. & Neut.	Fem.
N.	**два**	**две**	**три**	**четы́ре**	**оба**	**óбе**
G.	**двух**		**трёх**	**четырёх**	**обóих**	**обéих**
D.	**двум**		**трём**	**четырём**	**обóим**	**обéим**
A.	Like Nom. or Gen.				Like Nom. or Gen.	
I.	**двумя́**		**тремя́**	**четырьмя́**	**обóими**	**обéими**
P.	**(о) двух**		**трёх**	**четырёх**	**(об) обóих**	**обéих**

REMARKS. The plural of **одúн, однú, однé**, has the meaning of " some;" **одúн** also means " alone."

In compound cardinal numbers each term is separately declined :

200, **двéсти, двухсóт, двумстáм, двéсти, двумя́-стáми, (о) двух-стáх.**

21, **двáдцать одúн** (masc.) **двадцатú одногó, двадцатú одномý, двáдцать одногó** (or **одúн**), **двадцатью однúм, (о) двадцатú однóм.**

In compound ordinal numbers the last term only is ordinal and therefore is declined while all preceding terms are cardinal, like in English :

1859th—**ты́сяча восемьсóт пятьдеся́т ДЕВЯ́ТЫЙ, АЯ, ОЕ,** etc.

After **одúн** the noun stands in the nominative singular.

After the cardinal numbers—**два, три, четы́ре** and also **óба, óбе** (both), when used in the nominative or accusative, the following noun, when standing by itself, is put in the genitive singular; the qualifying adjective, however, is put in the nominative (rarely in the genitive) plural. From **пять** (5) onwards, when the number is nominative or accusative, both noun and adjective are put in the genitive plural:

Четы́ре человéка—four men.

Три красúвые (nom.) (or **красúвых**) **жéнщины**—Three beautiful women

Трúдцать пять большúх домóв—35 big houses.

FRACTIONS.

Fractions are formed as in English : a cardinal is used for the numerator and an ordinal for the denominator, in gen. pl. from 2 onwards:

one fifth—**однá пятая**
three sevenths—**три седьмы́х**

Note the following special forms:

one half—**половúна**
one third—**треть**
a quarter ($\frac{1}{4}$)—**чéтверть**
a hundred—**сóтня**
one and a half—**полторá**
a pair—**двóе, двóйка, пáра**
a dozen—**дюжина**
a set of three—**трóйка**
a set of four—**четвёрка**
once—**однáжды**
twice—**двáжды**
thrice—**трúжды** or **три рáза**
four times—**четы́ре рáза**
hundred times—**сто раз**
firstly—**во-пéрвых**
secondly—**во-вторы́х**
thirdly—**в трéтьих**

In counting, **раз** is used for one; **раз, два, три** etc.

To indicate an approximate number, the numeral is placed *after* the noun:

About four years—**гóда четы́ре**
About 20 roubles—**рублéй двáдцать**

HOW TO EXPRESS TIME.

What time is it?—**котóрый час?**

One o'clock; **час**. Two o'clock—**два часá**. Five o'clock —**пять часóв**. (**час**—an hour; **часы́**—a watch) Half-past ten—**половúна одúннадцатого** (lit. half of the 11th hour) Twenty past one—**двáдцать минýт вторóго** (lit. 20 minutes of the 2nd hour). Quarter past six—**чéтверть седьмóго** (lit. a quarter of the 7th hour). Quarter to nine **без чéтверти дéвять** (lit. nine without a quarter). Ten to two—**без десятú два** (lit. two without ten minutes). ' Hours ' and ' minutes ' are understood.

ýтро (morning) is used for from 6 a.m. to noon, approximately. **пóлдень** or **день** (afternoon) is used for from 12 noon to 6 p.m. (generally **день** means the day). **вéчер** (evening) is used for from 6 p.m. to midnight **ночь** (night) is used for from midnight to 6 a.m.

3 p.m.—**три часá дня** (or **по-полýдни**). 5 a.m.—**пять часóв нóчи** (or **утрá**).

HOW TO EXPRESS DATE.

On the 10th of October—**Деся́того Октября́.**
The first of June—**Пéрвое Июня.**

1936—**ты́сяча девятьсот тридцать шесто́й год.**

NOTE that the date is in neuter, because the word **число́** (number) is understood, and the English *on the* is expressed by the genitive case of the ordinal number: On the 25th of May—**Двадцать пя́того Ма́я.**

Letters are dated thus:

1st January, 1937—**1-го Января 1937 г.**
(pronounce: **пе́рвого января́ ты́сяча девятьсо́т три́дцать седьмо́го го́да**).

HOW TO EXPRESS AGE.

Age is expressed either by the nominative of the person and the genitive of the number of years: he is 13 years old—**он трина́дцати лет** (lit. he (is) of 13 years); or by the dative of the person and the nominative of the number: She is 20 years old **Ей два́дцать лет** (lit. to her twenty years).

О́т роду (since birth) are either added or understood.

I am now 30 years old—**мне тепе́рь три́дцать лет о́т роду** (lit. to me now thirty years from birth).

How old are you? **Ско́лько вам лет?** (lit. "how many summers to you?")

I am twenty one years old—**Мне два́дцать оди́н год.** (lit. "to me 21 years")

He was 35 years old on the 10th July, 1887—**Ему́ бы́ло три́дцать пять лет деся́того ию́ля ты́сяча восемьсо́т во́семьдесят седьмо́го года.**

HOW TO EXPRESS PRICE.

How much does this, that cost?—**ско́лько э́то, то сто́ит?**
15 roubles—**Пятна́дцать рубле́й.**
Three roubles each—**По́ три рубля́.**
Four stamps at one kopek each—**Четы́ре ма́рки по одно́й копе́йке.**

NOTE. Price is expressed by the Dative of the Number with the Preposition **ПО** (—at, at the rate), but the Numbers 2, 3, and 4 are put in the Accusative and take Genitive Singular of the Noun, as in the above examples.

PRONOUNS

Russian pronouns are declined, and their usage on the whole is the same as in English. The word **себя** (self) can be applied to any of the three persons. **Сам** is used before or after the word it qualifies: **я сам, сам я**, I myself.

The *Table* which follows may appear formidable, but all these words are of very frequent recurrence and must be mastered at this stage. Learn each word and its declension, writing out the English equivalent in accordance with the explanation of the cases given on pages 502-503

The initial **и** in **их, им, ими** is pronounced yee-.

NOTE. **ТВОЙ**, *thine*, and **СВОЙ**, *his*, are to be declined like **МОЙ**. **ВАШ**, *yours*, is declined like **НАШ**. **ЕГО́** (pr. yehvo'), *his*, its, **ЕЁ'**, *hers*, and **–ИХ**, *theirs*, are invariable throughout.

TABLE OF PRONOUNS.

	1	2	3	4	5	6	7	8
	I	THOU	HE (IT)	–SELF	MY MINE	OUR–S	THAT	THIS
MASCULINE AND NEUTER FORMS								
Nom.	Я	ТЫ	ОН (m.) ОНО́ (n.)	—	МОЙ (m.) МОЁ (n.)	НАШ (m.) НА́ШЕ (n.)	ТОТ (m.) ТО (n.)	Э́ТОТ (m.) ЭТО (n.)
Gen.	МЕНЯ́	ТЕБЯ́	ЕГО́	СЕБЯ́	МОЕГО́	НА́ШЕГО	ТОГО́	Э́ТОГО
Dat.	МНЕ	ТЕБЕ́	ЕМУ́	СЕБЕ́	МОЕМУ́	НА́ШЕМУ	ТОМУ́	Э́ТОМУ
Acc.	МЕНЯ́	ТЕБЯ́	ЕГО́	СЕБЯ́	МОЙ (m.) (МОЕГО́)* МОЁ (n.)	НАШ (m.) (НА́ШЕГО) НА́ШЕ (n.)	ТОТ (m.) (ТОГО́) ТО (n.)	Э́ТОТ (m.) (Э́ТОГО) Э́ТО (n.)
Ins.	МНОЙ (Ю)	ТОБО́Й (Ю)	ИМ	СОБО́Й (Ю)	МОИ́М	НА́ШИМ	ТЕМ	Э́ТИМ
Prep.	МНЕ	ТЕБЕ́	НЁМ	СЕБЕ́	МОЁМ	НА́ШЕМ	ТОМ	Э́ТОМ

* The form of Masculine Accusative in brackets is used in reference to animate beings.

FEMININE FORMS

Nom.	SAME AS MASCULINE		ОНА́ (she)	AS ABOVE	МОЯ́	НА́ША	ТА	Э́ТА
Gen.			ЕЁ		МОЕ́Й	НА́ШЕЙ	ТОЙ	Э́ТОЙ
Dat.			ЕЙ		МОЕ́Й	НА́ШЕЙ	ТОЙ	Э́ТОЙ
Acc.			ЕЁ		МОЮ́	НА́ШУ	ТУ	Э́ТУ
Ins.			ЕЙ (Ю)		МОЕ́Й (Ю)	НА́ШЕЙ (Ю)	ТОЙ (Ю)	Э́ТОЙ (Ю)
Prep.			НЕЙ		МОЕ́Й	НА́ШЕЙ	ТОЙ	Э́ТОЙ

TABLE OF PRONOUNS (continued).

PLURAL—ALL GENDERS

	1	2	3	4	5	6	7	8
Nom.	**МЫ**	**ВЫ**	**ОНИ́** (m.) **ОНЕ́** (f.)	AS ABOVE	**МОИ́**	**НА́ШИ**	**ТЕ**	**Э́ТИ**
Gen.	**НАС**	**ВАС**	**ИХ**		**МОИ́Х**	**НА́ШИХ**	**ТЕХ**	**Э́ТИХ**
Dat.	**НАМ**	**ВАМ**	**ИМ**		**МОИ́М**	**НА́ШИМ**	**ТЕМ**	**Э́ТИМ**
Acc.	**НАС**	**ВАС**	**ИХ**		**МОИ́** **(МОИ́Х)***	**НА́ШИ** **(НА́ШИХ)**	**ТЕ** **(ТЕХ)**	**Э́ТИ** **(Э́ТИХ)**
Ins.	**НА́МИ**	**ВА́МИ**	**И́МИ**		**МОИ́МИ**	**НА́ШИМИ**	**ТЕ́МИ**	**Э́ТИМИ**
Prep.	**НАС**	**ВАС**	**НИХ**		**МОИ́Х**	**НА́ШИХ**	**ТЕХ**	**Э́ТИХ**

MASCULINE AND NEUTER FORMS

	9 OF WHAT SORT IS?	10 WHICH?	11 WHOSE?	12 WHO?	13 WHAT?	14 ALL	15 SELF
Nom.	**КАКО́Й** (m.) **КАКО́Е** (n.)	**КОТО́РЫЙ** (m.) **КОТО́РОЕ** (n.)	**ЧЕЙ** (m.) **ЧЬЁ** (n.)	**КТО**	**ЧТО**	**ВЕСЬ** (m.) **ВСЁ** (n.)	**САМ** (m.) **САМО́** (n.)
Gen.	**КАКО́ГО**	**КОТО́РОГО**	**ЧЬЕГО́**	**КОГО́**	**ЧЕГО́**	**ВСЕГО́**	**САМОГО́**
Dat.	**КАКО́МУ**	**КОТО́РОМУ**	**ЧЬЕМУ́**	**КОМУ́**	**ЧЕМУ́**	**ВСЕМУ́**	**САМОМУ́**
Acc. *	**КАКО́Й** (m.) **(КАКО́ГО)*** **КАКО́Е** (n.)	**КОТО́РЫЙ** (m.) **(КОТО́РОГО)** **КОТО́РОЕ** (n.)	**ЧЕЙ** (m.) **(ЧЬЕГО́)** **ЧЬЁ** (n.)	**КОГО́**	**ЧТО**	**ВЕСЬ** (m.) **(ВСЕГО́)*** **ВСЁ** (n.)	**САМ** (m.) **(САМОГО́)*** **САМО́** (n.)
Ins.	**КАКИ́М**	**КОТО́РЫМ**	**ЧЬИМ**	**КЕМ**	**ЧЕМ**	**ВСЕМ**	**САМИ́М**
Prep.	**КАКО́М**	**КОТО́РОМ**	**ЧЬЁМ**	**КОМ**	**ЧЁМ**	**ВСЁМ**	**САМО́М**

FEMININE FORMS

	9	10	11	12	13	14	15
Nom.	**КАКА́Я**	**КОТО́РАЯ**	**ЧЬЯ**	AS ABOVE	AS ABOVE	**ВСЯ**	**САМА́**
Gen.	**КАКО́Й**	**КОТО́РОЙ**	**ЧЬЕЙ**			**ВСЕЙ**	**САМО́Й**
Dat.	**КАКОЙ**	**КОТО́РОЙ**	**ЧЬЕЙ**			**ВСЕЙ**	**САМО́Й**
Acc.	**КАКУ́Ю**	**КОТО́РУЮ**	**ЧЬЮ**			**ВСЮ**	**САМОЁ**
Ins.	**КАКО́Й (Ю)**	**КОТО́РОЙ (Ю)**	**ЧЬЕЙ (Ю)**			**ВСЕЙ (Ю)**	**САМО́Й (Ю)**
Prep.	**КАКО́Й**	**КОТО́РОЙ**	**ЧЬЕЙ**			**ВСЕЙ**	**САМО́Й**

PLURAL—ALL GENDERS

	9	10	11	12	13	14	15
Nom.	**КАКИ́Е**	**КОТО́РЫЕ**	**ЧЬИ́**	AS ABOVE	AS ABOVE	**ВСЕ**	**СА́МИ**
Gen.	**КАКИ́Х**	**КОТО́РЫХ**	**ЧЬИ́Х**			**ВСЕХ**	**САМИ́Х**
Dat.	**КАКИ́М**	**КОТО́РЫМ**	**ЧЬИ́М**			**ВСЕМ**	**САМИ́М**
Acc. *	**КАКИ́Е** **(КАКИ́Х)**	**КОТО́РЫЕ** **(КОТО́РЫХ)**	**ЧЬИ́** **(ЧЬИ́Х)**			**ВСЕ** **(ВСЕХ)**	**САМИ́Х**
Ins.	**КАКИ́МИ**	**КОТО́РЫМИ**	**ЧЬИ́МИ**			**ВСЕ́МИ**	**САМИ́МИ**
Prep.	**КАКИ́Х**	**КОТО́РЫХ**	**ЧЬИ́Х**			**ВСЕХ**	**САМИ́Х**

* The form of Masculine Accusative in brackets is used in reference to animate beings.

LESSON FOUR

The Verbs

"A verb is a word used for saying something about some person or thing" For example: The man drinks, the woman speaks, the child plays—drinks, speaks, plays are verbs.

The Russian verb is perhaps the most difficult part of the language. To master all its complexities and subtleties is for the foreigner a work of years. It is, however, a comfort to know that for practical purposes a limited knowledge is sufficient, and that, with a general knowledge of the structure, essential usages and most frequently used verbs, almost every situation can be coped with. What is given here is an absolute minimum and must be known thoroughly.

PARTS OF THE VERB WHICH MUST BE KNOWN.

(a) The *INFINITIVE*, i.e., "that part of the verb which names the action, without reference to any doer, and is therefore, not limited by person or by number." Thus: **де́лать**—to do; to make. **жела́ть**—to wish.

(b) The *PRESENT TENSE*, which represents the English forms I do, I wish; you do, you wish, etc. **я де́лаю, я жела́ю; ты де́лаешь, ты жела́ешь. . . . .**

(c) The *PAST TENSE* corresponding to the English I did, I wished, etc. **я де́лал, я жела́л. . . . .**

(d) The *FUTURE TENSE* corresponding to the English I shall do, I shall wish, etc. **я бу́ду де́лать, жела́ть. . . . .**

(e) The *IMPERATIVE* corresponding to the English command: Do—this or that! Speak! etc. **де́лай, жела́й.**

Most Russian verbs have two 'aspects' indicating either an *incompleted or continuous action* without regard to its beginning or end: as, for example, when we make the general statements 'I read books,' 'I receive letters,' 'I teach English.' This is called the *IMPERFECT ASPECT*. The other is the *PERFECT ASPECT* and it indicates that the action has been or will be *entirely completed* or has taken place only once: as, for example, when we say, "I have read a book," or "I will read a book."

Most of the essential Russian verbs are *IMPERFECTIVE*.

Imperfective verbs have a Present, Past and Future (Perfective Verbs have only a Past and a Future).

All forms of a Russian Verb are derived from the Infinitive, for which the endings are **–ть, –чь, –ти**, or **–чи**, thus:

писа́ть,	to write
мочь,	to be able
идти́,	to go.

The Present Tense has two main classes of endings for the different persons and numbers, thus:—

	Ist Conjugation	*2nd Conjugation*
	Я –у (or **ю**)	**–ю** (or **у** after hissing consonants **ж, ч, ш, щ**)
Thou	**Ты –ешь**	**–ишь**
He, she, it	**Он, она́, оно́ –ет**	**–ит**
We	**Мы –ем**	**–им**
You	**Вы –ете**	**–ите**
They	**Они –ут** (or **–ют**)	**–ят** (or **–ат**)

For example:

Ist Conjugation		2nd Conjugation	
(carry)	(read)	(speak)	(shout)
Я нес–у́	**чита́–ю**	**говор–ю́**	**крич–у́**
Ты нес ёшь	**чита–ешь**	**говор–и́шь**	**крич и́шь**
Он, она́, оно́ нес–ёт	**чита–ет**	**говор–и́т**	**крич–и́т**
Мы нес–ём	**чита–ем**	**говор–и́м**	**крич–и́м**
Вы нес–ёте	**чита́–ете**	**говор–и́те**	**крич–и́те**
Они нес–у́т	**чита–ют**	**говор–я́т**	**крич–а́т**

The Past Tense is formed by cutting off the Infinitive ending and substituting:

–л	masculine	for all persons in the singular
–ла	feminine	
–ло	neuter	

–ли for *all* genders and persons in the plural.

e.g

писа́–ть	(to write)	**люби́–ть**	(to love)
писа́–л, ла, ло **писа́–ли**	(wrote)	**люби́–л, ла, ло** **люби́–ли**	(loved)

The Future Tense is formed by using the future tense of the auxiliary verb **быть**—(to be) together with the Infinitive imperfective of the given verb.

Thus: **Я бу́ду чита́ть**—I shall read
Я бу́ду проси́ть—I shall ask.

The Imperative is formed by changing the ending of the second person present tense into **й** (in singular) and **–йте** (in plural) (or **–й** and **йте** after a vowel).

So:	**Де́лать**	to do	**Люби́–ть**	to love
	Ты де́лаешь	thou doest	**Вы лю́бите**	you love
Imperative:	**Де́лай** (singular) **Де́лайте** (plural)	Do!	**Люб–и́** **Люб–и́те**	love!

The third person of the imperative (let him, her, them do, etc.) is formed by using the word **пуска́й** or **пусть** (imperative of **пуска́ть**—to let, or allow) followed by the third person present tense, if the verb is imperfective, or the future tense, if the verb is perfective

Пусть он де́лает, Let him do (it). (imperfective)

Пусть они́ де́лают, Let them do.

Сре́зать—to cut off (perfective)

Пусть (or **пуска́й**) **он сре́жет, они́ сре́жут,** let him, (them), cut off (in future).

The above are the essential parts of a Russian verb. But there are others, the most important of which are the *Participles*.

A Participle represents a combination of verb and adjective, as when we say "a closed door:" 'closed' is a part of the verb 'to close' and is here used to qualify (or describe) door.

The Russian verb has two Participles, Present and Past, in both active and passive classes.

The Present active is formed by removing the –т of the third person plural present, and replacing it by: –щий (Masc.); –щая (Fem.); –щее (Neut.)

Example: Де́лают—They do
Pres. Part. Де́лающий—doing

The Past Participle (active) is formed by removing the –л of the Past Tense and replacing it by: –вший (Masc.); –вшая (Fem.); –вшее (Neut.)

Example: Говори́л—spoke
Past Part. Говори́вший—having spoken.

The present participle passive (in imperfective verbs) is formed by adding to the first person plural of the present tense the adjectival endings –ый, –ая, –ое, –ые.

(When the participles, like adjectives, are used as predicates these endings are omitted)

Мы лю́бим—we love
Люби́мый—loved, beloved
Мы жела́ем.—we wish жела́емый,—being wished

The past participle passive (in perfective verbs) is formed by adding to the root of the infinitive (i.e. after removing ть etc.) in most cases such endings as –тый, –ая, –ое, –ые, –ный, –ая, –ое, –ые, or –мый, etc.

When used as a predicate the same rule as above applies.

Убить—to kill, Уби́тый—killed. He (is) killed—Он уби́т. (See page 515. Formation of the Passive.)

THE PARTICIPLES ARE DECLINED AS ADJECTIVES (See pages 507-8). Hence, from every verb, it is possible to make at least two Adjectives, or, with the passive class—three.

CONJUGATION OF THE VERB.

As we have seen (page 513) there are two conjugations of Russian verbs, in accordance with the endings of the Present Tense (or future in perfective verbs). The first has ешь in the second person singular, and ут or ют in the third person plural.

To the first belong:—

(a) verbs of one syllable ending in –ть preceded by a vowel: врать—to tell lies; бить—to strike, etc.

(b) verbs ending –чь, –зть, –сть, –ти.

(c) verbs of more than one syllable ending in –ать, –ять, –очь, –нуть, –ереть.

To the second belong.

(a) verbs of more than one syllable ending –ить.

(b) verbs of more than one syllable ending in –ать preceded by a hissing sound (ж, ч, ш, щ), they take –у instead of –ю in the first person singular present.

MODEL VERBS

1st Conjugation

Жела́ть—To Wish

Present Tense

Я жела́ю	I wish
ты жела́ешь	thou wishest
он	he wishes
она́ } жела́ет	she wishes
оно́	it wishes
мы жела́ем	we wish
вы жела́ете	you wish
они жела́ют	they wish

Past Tense

Я жела́л, ла, ло	I wished
ты жела́л, ла, ло	thou wishedst
он жела́л	he wished
она́ жела́ла	she wished
оно́ жела́ло	it wished
мы жела́ли	we wished
вы жела́ли	you wished
они жела́ли	they wished

Future Tense

Я бу́ду жела́ть	I shall wish
ты бу́дешь жела́ть	thou wilt wish
он	he will wish
она́ } бу́дет жела́ть	she will wish
оно́	it will wish
мы бу́дем жела́ть	we shall wish
вы бу́дете жела́ть	you will wish
они бу́дут жела́ть	they will wish

Imperative

2. Sing жела́й—wish ! 2. Pl. жела́йте—wish
3. Sing пусть он, она́, оно́ жела́ет—let him, her, it wish
3. пусть они́ жела́ют—let them wish.

Present Participle

желающий, ая, ее—he, she, it that wishes, wishing.

Past Participle

жела́вший, ая, ее—he, she, it that wished, having wished

2nd Conjugation

Infinitive Говори́ть—To Speak

Present Tense

Я говорю́	I speak
ты говори́шь	thou speakest
он	he speaks
она́ } говори́т	she speaks
оно́	it speaks
мы говори́м	we speak
вы говори́те	you speak
они говоря́т	they speak

Past Tense

Я говори́л, ла, ло	I spoke
ты говори́л, ла, ло	thou spokest
он говорил	he spoke
она́ говори́ла	she spoke
оно́ говори́ло	it spoke
мы говори́ли	we spoke
вы говори́ли	you spoke
они говори́ли	they spoke

Future Tense

Я бу́ду говори́ть	I shall speak
ты бу́дешь говори́ть	thou wilt speak
он	he will speak
она́ } бу́дет говори́ть	she will speak
оно́	it will speak
мы бу́дем говори́ть	we shall speak
вы бу́дете говори́ть	you will speak
они бу́дут говори́ть	they will speak

Imperative

2. Sing. говори́—speak ! 2. Pl. говори́те—speak !
3. Sing. пусть он, она́, оно́ говори́т—let him, her, it speak
3. Pl. пусть они́ говоря́т—let them speak

Present Participle

говоря́щий, ая, ее—he, she, it that speaks, speaking.

Past Participle

говори́вший, ая, ее—he, she, it that spoke, having spoken.

ALL RUSSIAN VERBS FOLLOW THESE MODELS IN ACCORDANCE WITH THE RULES GIVEN.

The Perfective Aspect is in most cases formed from the Imperfective by the addition of a Prefix, such as по, про, при, на, у, etc.

Imperfective: писа́ть—to write; чита́ть—to read.
Perfective: написа́ть—to write; прочита́ть—to read through.

In some cases the imperfective is formed from perfective by adding a particle such as, ва before the infinitive ending ть. Thus:

уби́ть—to kill (instantaneously), perfective.
убива́ть—to kill (on several occasions), imperfective.

As mentioned before (page 513) the perfective form has no present tense, and its future tense, instead of being composite, is simple in form and follows the lines of Present Tense in imperfective form. Thus: уби́ть—to kill.

Future tense: Я убью́, ты убьёшь, он убьёт, мы убьём, вы убьёте, они убью́т.

NOTE that the verb уби́ть belongs to the *first* conjugation, because it is formed from the imperfective verb бить—to strike, hit,—which belongs to that conjugation in accordance with the rules given above (page 514)

FORMATION OF THE NEGATIVE.

To form the negative of the verb, put не immediately before it. Thus:

Я не люблю́ его́	I do not like him.
Я не де́лаю	I am not doing.
Ты не прийдёшь	Thou wilt not come.
Он не сиди́т	He is not sitting.

FORMATION OF THE INTERROGATIVE.

To ask a question, put the verb first, then the word ли (if, whether) and then the pronoun:

Де́лаю—ли я?	Am I doing ?
Хоти́те—ли вы?	Do you want ?
Убегу́т—ли они́?	Will they run away ?

FORMATION OF THE PASSIVE.

When a person or thing suffers an action from some other person or thing, the verb is said to be in the passive. Thus "the house *is built* by Jack"—"is built" is passive of the verb to build.

The Passive in Russian is formed by: (a) adding the verb "to be" (быть) to the passive participle (present in imperfective, past in perfective verbs), in instrumental case with the infinitive and in nominative case, with other forms of the verb.

Забыва́ть—to forget (imperfective).
Быть забыва́емым—to be forgotten.
Он не забыва́ем—He (is) not being forgotten.
Забы́ть—to forget (perfective).
Быть забы́тым—to be forgotten.
Я был забы́т—I was forgotten.

(b) by the use of the Reflexive Form (See below).
(c) by using the third Person Plural of the Present:

Говоря́т—(they) say, i.e., it is said.
Его́ зову́т—(they) call him, i.e., he is called.
Здесь говоря́т по—ру́сски—here (they) speak Russian—Russian is spoken here.

(b) and (c) are the commonest and easiest forms in everyday speech.

REFLEXIVE CONJUGATION.

A verb is reflexive (a) when its action is both performed and suffered by the subject ("I wash myself") and (b) when two pronouns instead of one are used in conjugation. In English there are few reflexive verbs, but there are many in Russian. Examples:

Роди́ть	to bear a child.
Роди́ться	to be born.

—the ending —ся (contraction of себя́ self) making the verb reflective (—ся after a vowel becomes —сь).

With these additions a reflective verb is conjugated exactly as a simple verb.

IMPERFECTIVE FORM

Умыва́ться—to wash oneself.

Present Tense

Singular	
Я умыва́юсь	I wash myself
ты умыва́ешься	thou washest thyself
он, —а́, —о́ умыва́ется	he, she, it washes himself, herself, itself
Plural	
мы умыва́емся	we wash ourselves
вы умыва́етесь	you wash yourselves
они умыва́ются	they wash themselves

Past Tense

Singular	
Я умыва́лся, лась	I washed myself
ты умыва́лся, лась	thou washedst thyself
он умыва́лся	he washed himself
она́ умыва́лась	she washed herself
оно́ умыва́лось	it washed itself
Plural	
мы умыва́лись	we washed ourselves
вы умыва́лись	you washed yourselves
они́ умыва́лись	they washed themselves

Future Tense

Singular	
Я бу́ду умыва́ться	I shall wash myself
ты бу́дешь умыва́ться	thou wilt wash thyself,
он бу́дет умыва́ться	he will wash himself
она́ бу́дет умыва́ться	she will wash herself
оно́ бу́дет умыва́ться	it will wash itself
Plural	
мы бу́дем умыва́ться	we shall wash ourselves
вы бу́дете умыва́ться	you will wash yourselves
они́ бу́дут умыва́ться	they will wash themselves

Imperative

Sing.	умыва́йся	wash thy self
Plur.	умыва́йтесь	wash yourself, —selves

PERFECTIVE FORM.

Умы́ться—to wash oneself

Present Tense

wanting

Past Tense

Singular		*Plural*
Я умы́лся, лась	I washed myself	мы умы́лись
ты умы́лся, лась	etc.	вы умы́лись
он умы́лся		они умы́лись
она́ умы́лась		
оно́ умы́лось		

Future Tense

Singular		*Plural*
Я умо́юсь	I shall wash myself	мы умо́емся
ты умо́ешься	etc.	вы умо́етесь
он, —а́, —о́, умо́ется		они умо́ются

Imperative

Sing. умо́йся	Plur. умо́йтесь

NOTE again that the bi-syllabic perfective verb **умы́ть (ся)** follows the conjugation of the mono-syllable imperfective verb **мыть**—to wash, from which it is derived.

NOTE the formation: **мыть** (imperfective), **умы́ть** (perfective), **умыва́ть** (imperfective), all three meaning to wash, with certain different shades (nuances).

AUXILIARY VERBS

The Russian verb " to have "—**име́ть** is *not* used as an auxiliary, but is used in the ordinary sense " to possess," or " to be possessed of." Apart from it " to be possessed of " is rendered by the third person present tense singular of the verb " to be " (the only part of this tense now in common use) in conjunction with a pronoun or noun denoting the possessing subject.

Singular	
I have	я име́ю or у меня́ есть
thou hast	ты име́ешь, у тебя́ есть
he, she, it has	он, она́, оно́ име́ет, or у него́, неё есть
Plural	
we have	мы име́ем, у нас есть
you have	вы име́ете, у вас есть
they have	они́ име́ют, у них есть.

There are three auxiliary verbs in Russian,

Infinitives	быть	to be (perfective)
	быва́ть	to be usually, or continually (imperfective).
	стать	to become, or begin.

Present Tense

(*perfective*) *Singular*	(*imperfective*) *Singular*	*Singular*
есть (is, there is)	Я быва́ю I am usually	wanting
	ты быва́ешь etc.	
	он, —а́, —о́, быва́ет	
	Plural	
	мы быва́ем	
	вы быва́ете	
	они́ быва́ют	

Past Tense

Singular	*Singular*	*Singular*
Я был, а́, о I was	Я быва́л, а, о	Я стал, а, о
ты был, а́, о etc.	ты быва́л, а, о	ты стал
он был	он быва́л	он стал
она́ была́	она́ быва́ла	она́ ста́ла
оно́ бы́ло	оно́ быва́ло	оно́ ста́ло

Plural	*Plural*	*Plural*
мы бы́ли	**мы быва́ли**	**мы ста́ли**
вы бы́ли	**вы быва́ли**	**вы ста́ли**
они́ бы́ли	**они́ быва́ли**	**они́ ста́ли**

Future Tense

Singular		*Singular*
Я бу́ду I shall or will be		**ста́ну**
ты бу́дешь etc.	Compound forms	**ста́нешь**
он, она́, оно́ бу́дет		**ста́нет**
Plural		*Plural*
мы бу́дем	**Я бу́ду быва́ть,**	**ста́нем**
вы бу́дете	etc.	**ста́нете**
они́ бу́дут		**ста́нут**

Imperative

2nd pers.		2nd pers.		2nd pers.	
Sing.	*Plur.*	*Sing.*	*Plur.*	*Sing.*	*Plur*
будь	**бу́дьте**	**быва́й**	**быва́йте**	**стань**	**ста́ньте**
3rd pers.		3rd pers.		3rd pers.	
Sing.	*Plur.*	*Sing.*	*Plur.*	*Sing.*	*Plur*
пусть бу́дет	**пусть бу́дут**	**пусть быва́ет**	**пусть быва́ют**	**пусть ста́нет**	**пусть ста́нут**
let him be	let them be				

Present Participle

Sing.	**су́щий, щая, щее**—which is	**быва́ющий, щая, щее**	wanting
Plur.	**су́щие**	**быва́ющие**	wanting

(*Future* **бу́дущий, щая, щее**)

Past Participle

Sing.	**бы́вший, шая, шее**—which was	**быва́вший, шая, шее**	**ста́вший, шая, шее**
Plur.	**бы́вшие**	**быва́вшие**	**ста́вшие**

Of the above verbs **быть** and its parts is the most important, as it is used to form compound tenses of other verbs.

In simple expressions the word "is" may be omitted altogether in Russian:

Я англича́нин—I (am) an Englishman.
Э́то моя́ жена́—This (is) my wife.
Что э́то?—What (is) this?
Кто э́то?—Who (is) this?

"Here is," "here are" are both expressed by the word **вот** (which corresponds to the French "Voici"):

Вот мой дом—Here (is) my house.

"Is there?" "Are there?" may be expressed by **есть**

Есть у вас бума́га?—Have you (is there by you) any paper?

N.B. **есть** is very commonly used in this sense in shops, restaurants, etc.

Есть у вас сего́дня бара́нина?—Have you to-day any mutton?

As a result of the frequent omission of **есть** many single Russian words represent whole phrases in English:

на́до—it is necessary
мо́жно—it is possible
хо́лодно—it is cold
тепло́—it is warm
бу́дет!—that is enough!
быва́ть—"to be usually" "to frequent" is useful.
Я быва́ю до́ма—I am usually (to be found) at home.
Он ча́сто быва́ет в теа́тре—He often goes to the theatre.

The future of **стать** (i.e. **ста́ну**) is frequently used to express the imperfective future:
Что ста́ну я де́лать?—what shall I do?, or **Что мне де́лать?** (liter. What to me to do?) in the same sense is used more frequently.

USEFUL VERBAL EXPRESSIONS.

дождь идёт—it is raining (literally, rain is going)
снег идёт—it is snowing
град идёт—it is hailing.
боли́т—it hurts.
хвата́ет—(Imperfective) It suffices.
хва́тит—(Perfective) It will suffice.
дово́льно—that is sufficient.
мо́жно—it is possible. one may.

Followed by an infinitive, **можно** is the equivalent of the English "It is permitted to . . ."

Мо́жно говори́ть, кури́ть—Speaking, smoking is permitted.
нельзя́—is the opposite to **мо́жно**.
нельзя́ разгова́ривать—talking is forbidden.
изве́стно—it is known (that). . .
состои́тся—there will take place . . .
состои́т—it consists of . . .
сле́дует—it follows (that) . .

сле́дует is also often used in the sense of "it is due:"
мне сле́дует с вас два́дцать фу́нтов—it is due to me from you twenty pounds (£20)

Before proceeding to the Irregular Verbs and the Perfective and Imperfective forms of essential verbs, it will be found advisable to go over again all that has been given about verbs up to this point. To start learning irregularities before the normal and regular forms are very well known would obviously be confusing.

IRREGULAR VERBS

The following is a list of essential Irregular Verbs and their principal parts, both in imperfective and perfective forms. The list is for reference purposes.

INFINITIVE		INDICATIVE					IMPERATIVE	
Imperfective	*Perfective*	*Present Imperf.*		*Past Imperf.*	*Past Perf.*	*Fut. Perf.*	*Imperf.*	*Perf.*
		1st pers.	2nd pers.					
бере́чь, to protect, preserve	**сбере́чь**	**берегу́,**	**бережёшь**	**берёг**	**сберёг**	**сберегу́**	**береги́**	**сбереги́**
брать, to take	**взять**	**беру́,**	**берёшь**	**брал**	**взял**	**возьму́**	**бери́**	**возьми́**
везти́, to carry, convey	**повезти́**	**везу́,**	**везёшь**	**вёз**	**повёз**	**повезу́**	**вези́**	**повези́**
вести́, to lead, conduct	**повести́**	**веду́,**	**ведёшь**	**вёл**	**повёл**	**поведу́**	**веди́**	**поведи́**
дава́ть, to give	**дать**	**даю́,**	**даёшь**	**дава́л**	**дал**	**дам**	**дава́й**	**дай**
есть, to eat	**съесть**	[1] **ем, ешь,** **ест**	[2] **еди́м,** **еди́те, едя́т**	**ел**	**съел**	**съем**	**ешь**	**съешь**
е́хать, to drive, to go (in a vehicle)	**пое́хать**	**е́ду,** **е́дешь,** **е́дет**	**е́дем,** **е́дете,** **е́дут**	**е́хал**	**пое́хал**	**пое́ду**	——	**поежа́й**
итти́, to go	**пойти́**	**иду́,**	**идёшь**	**шёл**	**пошёл**	**пойду́**	**иди́**	**пойди́**
класть, to put, lay	**положи́ть**	**кладу́,**	**кладёшь**	**клал**	**положи́л**	**положу́**	**клади́**	**положи́**
лезть, to climb, creep	**поле́зть**	**ле́зу,**	**ле́зешь**	**лез**	**поле́з**	**поле́зу**	**лезь**	**поле́зь**
ложи́ться, to lie down	**лечь**	**ложу́сь,**	**ложи́шься**	**ложи́лся**	**лёг**	**ля́гу**	**ложи́сь**	**ляг**
мочь, to be able	**смочь**	**могу́,**	**мо́жешь**	**мог**	**смог**	**смогу́**	——	——
нести́, to bear, carry	**понести́**	**несу́,**	**несёшь**	**нёс**	**понёс**	**понесу́**	**неси́**	**понеси́**
печь, to bake	**испе́чь**	**пеку́,**	**печёшь**	**пёк**	**испёк**	**испеку́**	**пеки́**	**испеки́**
расти́, to grow	**вы́рости**	**расту́,**	**растёшь**	**рос**	**вы́рос**	**вы́росту**	**расти́**	**вы́рости**
сади́ться, to sit down	**сесть**	**сажу́сь,**	**сади́шься**	**сади́лся**	**сел**	**ся́ду**	**сади́сь**	**сядь**
стере́чь, to guard	**постере́чь**	**стерегу́,**	**стережёшь**	**стерёг**	**постерёг**	**постерегу́**	**стереги́**	**постереги́**
спаса́ть, to save	**спасти́**	**спаса́ю,**	**спаса́ешь**	**спаса́л**	**спас**	**спасу́**	**спаса́й**	**спаси́**
стричь, to shear, to cut (hair)	**остри́чь**	**стригу́,**	**стрижёшь**	**стриг**	**остри́г**	**острогу́**	**стриги́**	**остриги́**
тере́ть, to rub	**потере́ть**	**тру,**	**трёшь**	**тёр**	**потёр**	**потру́**	**три**	**потри́**
трясти́, to shake	**потрясти́**	**трясу́,**	**трясёшь**	**тряс**	**потря́с**	**потрясу́**	**тряси́**	**потряси́**
умира́ть, to die	**умере́ть**	**умира́ю,**	**умира́ешь**	**умира́л**	**у́мер**	**умру́**	**умира́й**	**умри́**

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[1] Singular. [2] Plural.

From the parts of each verb given above, all the other parts can be formed—see Rules on pages 513-514.

Note.—The beginner need not, for a start, attempt to memorise this table : but he should not fail to refer to it continually, until the parts are known.

IMPERFECTIVE FORM OF ESSENTIAL VERBS AND THE CORRESPONDING PERFECTIVE FORM

бежа́ть—to run, **побежа́ть**
бить—to beat, **поби́ть**
благодари́ть—to thank, **поблагодари́ть**
благословля́ть—to bless, **благослови́ть**
боле́ть—to be ill, **заболе́ть** (to fall ill)
боя́ться—to fear, **побоя́ться**
брать—to take, **взять**
брить—to shave, **побри́ть**
броди́ть—to wander, **поброди́ть**
броса́ть—to throw, **бро́сить**
буди́ть—to waken, **разбуди́ть**
быть—to be, **побы́ть** (to remain)
верте́ть—to turn, **поверте́ть**
ви́деть—to see, **уви́деть**
внуша́ть—to suggest, **внуши́ть**
води́ть—to lead, **вести́**
врать—to tell a lie, **совра́ть**
встава́ть—to rise, **встать**
встреча́ть—to meet, **встре́тить**
входи́ть—to come in, **войти́**
выбира́ть—to choose, **вы́брать**
ве́сить—to weigh, **све́сить**
гнить—to rot, **сгнить**
говори́ть—to speak, **поговори́ть**

грузи́ть—to load, погрузи́ть
держа́ть—to hold, подержа́ть
достава́ть—to get, obtain, доста́ть
ду́мать—to think, поду́мать
де́лать—to do, make, сде́лать
е́хать—to go, to drive, пое́хать
ждать—to wait, expect, подожда́ть
жела́ть—to desire, пожела́ть
жить—to live, пожи́ть
забавля́ть—to amuse, заба́вить
заболева́ть—to become ill, заболе́ть
зажига́ть—to light (lamp), to set on fire, заже́чь
закрыва́ть—to shut, close, закры́ть
замеча́ть—to perceive, заме́тить
запи́сывать—to inscribe, to record, записа́ть
заслу́живать—to merit, deserve, заслужи́ть
звать—to call, invite, позва́ть
знать—to know, узна́ть
игра́ть—to play, поигра́ть
избира́ть—to elect, избра́ть
извиня́ть—to forgive, извини́ть
извеща́ть—to inform, извести́ть
класть—to put, положи́ть
конча́ть—to finish, ко́нчить, око́нчить
лгать—to tell lies, солга́ть
ме́рить—to measure, изме́рить
писа́ть—to write, написа́ть
пить—to drink, вы́пить
плати́ть—to pay, заплати́ть
пла́кать—to weep, запла́кать
пока́зывать—to show, показа́ть
покида́ть—to leave, поки́нуть
покупа́ть—to buy, купи́ть
понима́ть—to understand, поня́ть
по́ртить—to spoil, испо́ртить
посыла́ть—to send, посла́ть
предлага́ть—to offer, bid, предложи́ть
принима́ть—to accept, приня́ть
приготовля́ть—to prepare, пригото́вить
продава́ть—to sell, прода́ть
петь—to sing, спеть
ре́зать—to cut, поре́зать
слы́шать—to hear, listen, услы́шать
спеши́ть—to hasten, поспеши́ть
стро́ить—to build, постро́ить
уме́ть—to be able to, суме́ть
утомля́ть—to tire, утоми́ть
щади́ть—to spare, пощади́ть

NOTE : Although this list must be known—and as soon as possible—the student is advised not to attempt to memorise it immediately. He should, however, refer to it again and again, as it is important to know both forms of these common verbs.

LESSON FIVE

Adverbs, Prepositions, Conjunctions

An adverb is a word used to qualify any part of speech except a noun or pronoun.

In English most adverbs end in -LY. In Russian the usual adverbial ending is –О which replaces the adjectival endings (–ЫЙ, –ОЙ, –ИЙ).

Thus :

Adjective: хоро́ший, good.
Adverb: хорошо́, well.

‘ Soft ’ Adjectives take –E instead of –О

Adjective: кра́йний, extreme
Adverb: кра́йне, extremely.

In other words, the adverb is generally the same as he nominative singular neuter of the short form of djectives.

The Instrumental Case of some Nouns can be used s an adverb.

ве́чером, in the evening.
днём, by day.
но́чью, by night.
у́тром, in the morning.

NOTE. The adverbs derived from the noun дом (house, home)

домо́й home (иду́ домо́й—I am going home).
до́ма—at home (он остаётся до́ма—he remains at home).

The Comparative and Superlative of adverbs are the same as the corresponding “ short ” form of the adjective:

хорошо́, well; лу́чше, better; всего лу́чше, best

NOTE: мно́го—much; бо́лее—more; бо́лее всего́—most;
ма́ло—little; ме́нее or ме́ньше—less.
наибо́лее, the most (adverb)
наиме́нее, the least (adverb)

Adverbs are often formed from adjectives by placing the prefix по- and changing the ending to –и

По-ру́сски, in Russian
Говори́те-ли вы по-ру́сски? Do you speak Russian?

After

мнóго, much, many
мáло, few, little
немнóго, a few
скóлько, How much? How many?
стóлько, as much, many
нéсколько, some

The noun which follows is in the genitive plural.

довóльно, enough

Скóлько жителей в Лóндоне? How many inhabitants (are there) in London?

У негó мнóго дéнег. He has much money.

LIST OF ESSENTIAL ADVERBS.

да, yes.
нет, no.
ни—ни, neither, nor.
в сáмом дéле, indeed.
нискóлько, not at all.
конéчно, of course.
когдá, when.
докóле, how long.
где, where.
откýда, whence.
здесь, here.
там, there.
нигдé, nowhere.
вездé, everywhere.
сюдá, hither.
тудá, thither.
отсю́да, from here, hence.
оттýда, from there.
дóма, at home.
домóй, home.
хорошó, well.
скóро, quickly.
и́наче, otherwise.
наугáд, at random.
нарóчно, intentionally.

вчерá, yesterday.
сегóдня, to-day.
зáвтра, to-morrow.
пóсле зáвтра, the day after to-morrow.
трéтьего дня, the day before yesterday.
ны́не, at present.
тепéрь, now.
прéжде, before.
пóсле, afterwards.
рáно, early.
ýтром, in the morning.
вéчером, in the evening.
вскóре, soon.
мáло, little.
мнóго, much.
тóлько, only.
почти́, nearly.

весьмá, **óчень**, highly, very.
сли́шком, too, too much.
вóвсе, entirely, at all.
чрезвычáйно, exceedingly, excessively.
чтó-то, somewhat.

The above are of frequent occurrence and should be memorized.

ADVERBIAL PARTICIPLES.

Participles of Russian verbs have adverbial forms which are formed by dropping the participle endings: **—щий** in the present, and **—ший**, or **—й** in the past.

Present :

Люб-и́ть, to love; **лю́бящий**, loving; **любя́**, loving, while or by loving.

Говор-и́ть, to speak; **говоря́щий**, speaking; **говоря́** speaking, when speaking.

Говоря́ о снéге, я вспóмнил Росси́ю—While speaking of snow I remembered Russia.

Past :

Ударить, to strike, to hit; **удáривший**, having struck **удáрив** or **удáривши**.

Повернýть, to turn; **повернýвший**, having turned **повернýв** or **повернýвши**.

Повернýвши к немý гóлову, он сказáл—Having turned t him (the head), he said.

While adverbial in form, these participles express mode of action.

PREPOSITIONS

A Preposition is a word placed before a noun t show in what relation the person or thing denote thereby stands to something else.

In Russian, prepositions are very frequently used t make compound words (especially verbs) and although such compound words may have a meaning which approximates to the simple meaning of th preposition plus the original word, yet the resultan meaning *is so often entirely different and remote* that i is advisable for the student to learn each compoun as if it were an *entirely new word*. Thus:

Noun : **мéна**, exchange, barter.

Compound nouns: **перемéна**, alteration (**пере**, over).
измéна, treason (**из**, out).

Compound verbs: **перемени́ть**, to alter.
измени́ть, to betray.

Certain prepositions are joined with a word and become inseparable. They are :

воз—, **взо—**, or, **вз—**,	meaning up.
низ—,	down.
пере—,	over.
раз—,	asunder.

These four prepositions are *only* used for making compound words and require no particular case after them.

ALL OTHER RUSSIAN PREPOSITIONS GOVERN (that is must be followed by) A CASE, and some o them govern two or three cases, in accordance with the meaning to be conveyed.

LIST OF ESSENTIAL PREPOSITIONS.

I. Governing one case only :

про, concerning
через, over, across
сквозь, through

Followed by the the Accusative.

без, without
для, because of, for
из, out of
ради, for sake of
до, up to, until
от, from, away
у, at

Govern the Genitive.

над (sometimes **на́до** for euphony) over, upon. Governs the Instrumental.

при, near, in the presence of. Governs the Prepositional (or Locative).

без–, when combined with any word gives the equivalent of English opposite meaning in–, un–, a–, less: **безбо́жник**—atheist.

из–, with a verb means out of (also " outright").

у–, with a verb means away, etc.

2. Prepositions which Govern Two Cases.

(a) Accusative and Instrumental

за, behind, beyond (*with verbs* conveys the meaning of both beginning and completion).

пред, пе́ред, before (time or place).

под, under.

(b) Accusative and Locative.

в, во, in, into.

на, on, against.

о, об, concerning, around.

NOTE: The Accusative conveys " motion to;" the Instrumental or Locative "rest in " or " at."

(c) Genitive and Instrumental

ме́жду, among, between.

3. Prepositions which govern Three Cases.

(a) Accusative, Genitive and Instrumental.

с (со)
- as (Acc.)—*in comparison*, " about " (time).
- from (Gen.)—from, motion down from.
- with (Instr.).
- *with verbs*,—simultaneity, movement downwards, completion.

(b) Accusative, Dative, and Locative

по
- up to (Acc.)
- along (Dat.).
- over, after (Loc.)
- *with verbs*—repetition.

NOTE. **По** also changes an Imperfective verb into a Perfective one.

Слу́шать—to listen. **Послу́шать**—to listen (in perfective sense).

Examples: **Че́рез забо́р**—across the hedge. **Сквозь окно́**—through the window. **Без хле́ба**—without bread. **Для нау́ки**—for the science. **Из ко́мнаты**—out of the room. **Ра́ди челове́чества**—for the sakè of humanity. **До го́рода**—up to the city. **От него́**—from him. **У меня́**—at (or by) me. **За стено́ю**—behind the wall, **Пе́ред заре́й**—before the dawn. **Под столо́м**—under the table. **В до́ме**—in the house. **Во вто́рник**—on Tuesday. **На кры́ше**—on the roof. **О челове́ке**—concerning the man. **Ме́жду друзья́ми**—among friends **Со сту́ла**—from the chair. **С кни́гой**—with a book. **По доро́ге**—along the road.

Prepositions are very frequently recurring words, and the above list must be memorised.

CONJUNCTIONS

Conjunctions are words used for connecting either words or sentences. ' The man *and* the woman went home, *but* only the woman remained there:' " and " and " but " are conjunctions. In Russian they have no particular rules governing their usage, and the student has merely to learn the list which follows.

LIST OF ESSENTIAL CONJUNCTIONS

а, and, but
и, and
и . . . и, both . . . and
ли, if, whether
ни . . . ни, neither . . . nor
но, but
иль, или, or
и́бо, because
ли́бо, either, or
да́же, even
ещё, still, yet
е́сли, when, if
е́жели, if
не́жели, than
никогда́, never
что́бы, in order that
чем, than
е́сли–бы, if
потому́ что, because
то, then
то . . . то, sometimes . . . sometimes
чем . . . тем, the more . . the more
что, that
то́лько, only, merely
как, as, when
хотя́, although
пусть / **пуска́й** / **бы** } let

INTERJECTIONS

Affirmation: **Да**, " Yes." **Коне́чно**, " Of course."
Assurance: **Ей, пра́во**, " Indeed." " Upon my word."
Aversion: **Фу**, " Faugh!"
Call: **Эй, гей**, " Halloa!"
Compulsion: **Ну!** *plur.* **ну́–те**, " Come!" **Ну–же**, " Now then."
Encouragement: **Сла́вно!** " Glorious." **Ура́**, " Hurrah."
Grief: **Ах! Ох!** "Ah!" " Oh!" **Го́ре, беда́, увы́**, " Alas."
Indication: **Вот**, " There."[1] **Вон**, " Out."
Indignation: **Тьфу**, " Fie."
Offer: **На**, *plur.* **на́–те**, " Take it."
Pity: **Жаль**, " What a pity."
Prohibition: **Ст! Тс!** " Hush." **Молча́ть!** " Silence!"
Refusal: **Нет**, " No."
Repulsion: **Прочь!** " Off." **Доло́й**, "Away " **По́лно**, " Cease," " stop."
Surprise: **А! Ах!** " Ah!" **Ба**, " Oh."

NOTE. It is hardly possible to compute the frequency of recurrence of the above expressions, but one may assert with some confidence that in both English and Russian (especially the latter) they are useful.

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[1] **Вот** has a meaning equivalent to the French " Voici "—Here is. . . . .

LESSON SIX

Word Building

It is possible by means of endings or prefixes (some of which are used separately as prepositions) to vary the meaning of almost every part of speech in Russian :

PREFIXES

Воз, вос, взо indicates movement *up*: ходи́ть, to walk; восходи́ть, to arise.

Вы indicates movement *outwards*, separation: брать, to take; вы́брать, to take out, to choose: вози́ть (везти́), to drive, carry: вы́воз, the exportation; вывози́ть to export.

Низ (нис), indicates downward movement: низложи́ть, to depose, to dethrone; (ложи́ть, to lay down).

Пере, indicates change, movement across: ду́мать, to think; переду́мать, to change one's thinking, i.e. mind, opinion: бежа́ть, to run; перебежа́ть, to run-across.

Раз (рас), indicates separation or undoing: бить, to strike, hit; разби́ть, to strike or break in pieces, defeat: вяза́ть, to bind; развяза́ть, to undo, to untie.

Also forms the perfective aspect of many verbs: разбогате́ть, to be enriched; (богате́ть, to become rich).

These prefixes can be added to hundreds of words (especially verbs) and form numerous other words or shades of meaning of one and the same word. The above prefixes are not used separately, or alone.

ENDINGS.

The following endings may be added to Nouns in order to change their meaning:

1. To Form Patronymics.

Masculine.

—ич, —ович, —евич, ' son of:'

Фома (Thomas) Фоми́ч (Thomas's son).
Пётр (Peter) Петро́вич.
Алексе́й (Alexis) Алексе́евич.

Feminine.

—инична, —овна, —евна, 'daughter of:

Фоми́нична, Петро́вна, Алексе́евна (daughter of Thomas, etc.).

2. To Form Diminutives or Denote Affection.

Masculine and Feminine.

—енька, —ёнка, —очка, —ушка, —юшка, —ишка (little, dear): па́пенька, dear father; ма́менька, dear mother; сестрёнка, little sister, from сестра́—sister; ма́мочка, little mother; де́душка, grand-father; ба́бушка. grand-mother; ба́тюшка, daddy, little father; мальчи́шка, little boy, from ма́льчи boy.

Neuter

—ко, —цо: ведёрко, little pail, from ведро́, pail: о́блачко, little cloud, from о́блако, cloud; письмецо́, little or brie letter, from письмо́, letter.

3. To denote Depreciation or Derogation.

—ишка, —ишко, —онка, —ёнка: вори́шка, little thief, from вор, thief; доми́шко, small (poor) house, from дом, house; книжо́нка, insignificant book, from кни́га, book; избёнка poor little peasant's house, from изба́, hut, peasant' house.

4. To denote Increase in Size or Largeness.

—ища, —ище, —ина: ручи́ща, large hand, from рука́,[1] hand arm; волчи́ще, big wolf, from волк,[1] wolf; доми́на, big house.

5. Indicating Place where an action is carried on

—ня: пе́карь, baker; пека́рня, bakehouse.
—лище: учи́ть, to teach; учи́лище, school.

6. Indicating the Inhabitant of a Place.

	Masculine.			*Feminine.*
—ец:	Италья́нец	an Italian	—ка,	Италья́нка
—анин:	Парижа́нин	a Parisian	—ка,	Парижа́нка
—ак:	Прусса́к	a Prussian	—ачка,	Прусса́чка

7. Indicating Physical or Mental Characteristics.

	Masculine		*Feminine*
—ун:	(derogatory) хвасту́н, braggart (verb хва́стать, to boast).		хвасту́нья
—як:	(fellow) добря́к, good sort (adjective до́брый, good).	—ячка:	добря́чка

8. To make Abstract Nouns.

—ина:	дли́нный, long:	длина́, length.
—ость:	рад, glad:	ра́дость, joy.
—ство:	бога́тый rich:	бога́тство, wealth.
—а:	свобо́дный, free:	свобо́да, freedom.

9. The Following Endings are added to Nouns to Make Adjectives.

Ending	*Noun*	*Adjective*
—кий	жар, heat:	жа́ркий, hot.
—ский	челове́к, man:	челове́ческий.[1] human.
	конь horse:	ко́нский, of horse, equine.
—истый	духи́ (plural) perfume:	души́стый,[1] perfumed.

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[1] NOTE: "Guttural" consonants—г, к, х, when followed in derivative words by a soft vowel are mostly changed into corresponding "hissing" consonant—ж, ч, ш.

—янный	**де́рево**, wood:	**деревя́нный**, wooden.
—ев, (—ов)	**царь**, king; tsar.	**ца́рев** and **ца́рский**, king's, royal.
—ин, иный	**дя́дя**, uncle:	**дя́дин**, uncle's.
	ло́шадь, horse:	**лошади́ный**, of horse.

Refer to pages 520-21, Prepositions. As we have seen, certain prepositions when put before verbs have the effect of modifying the aspect and sometimes change the entire meaning of the verb. The same refers to some other parts of speech as well. Consider the following:—

БЕЗ (БЕС)—WITHOUT, expresses the opposite to simple word:

беспоко́ить, to trouble, to disquieten, (noun **поко́й** means ' rest,' ' quietness).

В (ВО)—IN, AT, indicates movement inwards:

войти́, to go in (**итти́**, to go).

вноси́ть, to bring in (**носи́ть**, to carry).

ДО—TO, UP TO, indicates attainment of end or completion of action.

догна́ть, to rejoin, overtake.

договори́ть, to finish speaking (**говори́ть**, to speak).

дописа́ть, to finish writing (**писа́ть**, to write).

ЗА—BEYOND, AFTER indicates situation beyond:

замо́рский, beyond the seas (**мо́ре**, the sea).

ИЗ (ИС)—FROM, OUT OF:

изгна́ть, to expel (**гнать**, to drive).

НА—ON denotes action on a surface:

написа́ть, to write (upon).

напи́ться, to drink one's full, to get drunk. (**пить**, to drink).

НАД—OVER, ABOVE:

на́дпись, the inscription, endorsement.

надзо́р, the surveillance.

О, (ОБ, ОБО)—ABOUT, means movement round an object:

обходи́ть, to go round (**ходи́ть**, to walk, go).

ОТ—FROM, denotes separation, movement away:

отлива́ть, to flow out, **отли́в**, the outflow, ebb, low tide (**лить**, to pour).

отдели́ть, to detach, separate (**дели́ть**, to divide).

отговори́ть, to dissuade.

ПО—AFTER, ABOUT, indicates indefinite duration of action:

поговори́ть, to speak a little

or perfective aspect of verbs:

полюби́ть, to fall in love (**люби́ть**, to love).

ПОД—UNDER, means motion under or towards:

подходи́ть, to approach.

or addition:

подли́ть, to pour in (more).

ПРЕД—BEFORE, IN FRONT OF, priority:

предсказа́ть, to foretell (**сказа́ть**, to say, to tell).

ПРИ—AT, indicates approximation, addition:

приводи́ть, to bring to (**води́ть**, to lead).

прие́хать, to arrive (not on foot) **прие́зд**, the arrival (**е́хать**, to go, to ride).

прили́в, the inflow, high tide.

ПРО—ABOUT, means passage through, across:

проходи́ть, to pass, to go through.

or completion of action:

прочита́ть, to read through (**чита́ть**, to read).

проигра́ть, to lose at game (**игра́ть**, to play).

С (СО)—WITH, denotes simultaneity, cooperation:

совреме́нник, contemporary (**вре́мя**, the time).

or forms the Perfective aspect:

сде́лать, to have made. (**де́лать**, to do, to make).

У—AT, WITH, denotes removal:

улета́ть, to fly *away* (**лета́ть**, to fly).

or removal of part:

уре́зать, to cut a *piece* (**ре́зать** to cut).

or perfective aspect, or end of action:

умори́ть, to starve to death (**мори́ть**, the same in imperfective aspect).

укра́сть, to have stolen (**красть**, to steal)

or increase:

уси́лить, to strengthen (**си́ла**, the strength, force).

NOTE:

This chapter on ' Word Building ' is intended to be for reference. Yet it is of great importance. The student will realise that, with the prefixes and suffixes given above, and the vocabulary of essential words, the key is provided to the meaning of thousands of words. When the elements of grammar have been mastered, the only serious problem remaining is that of vocabulary, of which the principles of word-building are an essential.

FORMS OF ADDRESS AND NAMES IN RUSSIAN

The word **ВЫ** is the general equivalent for the English word *YOU* and it is the form of address which should always be used by the foreigner in addressing adults. It requires the verb to be in the second person plural : **Говори́те–ли вы по–а́нглийски?**—Do you speak English?

ТЫ thou, is used between relations, intimate friends, in addressing children, animals, the Deity (and pre-revolution in speaking to servants, or by officers speaking to privates etc.)

Уме́ешь–ли ты писа́ть?—Can you write? (to a child).

The plural of **ТЫ** is **ВЫ** and is used to address two or more people to whom **ТЫ** would apply.

EQUIVALENTS FOR MR., SIR, ETC.

Mr. and Sir are expressed by **ГОСПОДИ́Н**, Mrs. and Lady—by **ГОСПОЖА́** which are used *with surnames only:* **ГОСПОДИ́Н ИВА́НОВ**—Mr. Ivanoff. **ГОСПОЖА́**

ПЕТРО́ВА—Mrs. Petroff. When persons are not intimate enough to address each other by Christian names [**ПОСЛУ́ШАЙ, ИВА́Н**—Look here (listen) John] the usual form of address is the interlocutor's first name coupled with his or her patronymic, which means "son, or daughter of:" **ИВА́Н СЕРГЕ́ЕВИЧ** (or shorter **СЕРГЕ́ИЧ**)—John Serge's son. **МАРИ́Я ПЕТРО́ВНА**—Mary, Peter's daughter. This is less formal than « **ГОСПОДИ́Н ИВА́НОВ** »—Mr. Ivanoff.

In Soviet Russia to address someone or to be addressed as **ГОСПОДИ́Н, ГОСПОЖА́** is interpreted as a sign of bourgeois mentality or counter-revolution and is to be avoided. Its place is taken by **ГРАЖДАНИ́Н, ГРАЖДА́НКА**—Citizen, Citizeness, or among Communists (members of the party) or State employees or workmen—**ТОВА́РИЩ**—'comrade,'—for both sexes.

ГОСПОДИ́Н and **ГРАЖДАНИ́Н** are shortened in written address to **Г.** or **Г-Н**; **ГОСПОЖА́** into **Г-ЖА**, **ГРАЖДА́НКА** into **Г-КА.**

In pre-Revolutionary times, servants, peasants etc., used to address their masters or superiors as **БА́РИН**—Mr., Sir, my Lord, **БА́РЫНЯ**—Mrs., my Lady, **БА́РЫШНЯ**—miss, my lady, *without adding* either the Christian name or the surname.

CORRESPONDENCE

The date is written thus: **10-го ИЮЛЯ 1933 г.**—*of* 10th July 1933, and is pronounced always as ordinal genitive: **ДЕСЯ́ТОГО ИЮЛЯ**—of the tenth of July, the year being pronounced as cardinal for every component figure except the last which is ordinal—**ТЫ́СЯЧА ДЕВЯТЬСО́Т ТРИ́ДЦАТЬ ТРЕ́ТЬЕГО ГО́ДА**—thousand nine hundred thirty OF THIRD year.

(1) A formal opening: **МИ́ЛОСТИВЫЙ ГОСУДАРЬ**—(no longer used in Soviet Russia, as being too reminiscent of the "old regime")—Dear Sir (literally—Gracious Lord). **МИ́ЛОСТИВАЯ ГОСУДА́РЫНЯ**—(ditto)—Dear Madam. **МИ́ЛОСТИВЫЕ ГОСУДА́РИ**—plural to a firm.

(2) Less formal, and used in the U.S.S.R: **МНОГОУВАЖА́ЕМЫЙ ГОСПОДИ́Н / ГРАЖДАНИ́Н / ИВА́НОВ**—Much esteemed Mr. (Citizen) Ivanoff. **МНОГОУВАЖА́ЕМАЯ А́ННА ВАСИ́ЛЬЕВНА**—Much esteemed Anna Basil's daughter.

(3) A familiar opening: **ДОРОГО́Й СЕРГЕ́Й СЕМЕ̂НОВИЧ**—Dear Serge son of Simon. An intimate opening: **ДОРОГО́Й ИВА́Н**—Dear John. **МИ́ЛАЯ ТА́НЯ**—Cherished Tania (pet-name for Tatiana).

(4) A formal ending: **С СОВЕРШЕ́ННЫМ ПОЧТЕ́НИЕМ, С СОВЕРШЕ́ННЫМ УВАЖЕ́НИЕМ**—yours faithfully, truly (literally—with perfect esteem, consideration).

(5) Less formal: **ПРЕ́ДАННЫЙ ВАМ / ТЕБЕ́ /**—Devoted to you (thou).

(2) and (4) are the openings and endings which should be used until the student is thoroughly familiar with Soviet usage.

LESSON SEVEN

Vocabulary: Days, Months, Names

For practical purposes, it is necessary to know the pronouns, the numbers, certain adverbs, prepositions and conjunctions (all given in earlier Lessons) the names of the days of the week, the months and seasons, a few common idioms—and the words in large type in the Alphabetical List in Lesson 8. The student will then have a practical working vocabulary of about 1,600 words. Other words in small type in the Alphabetical List may afterwards be memorized. Used in accordance with the rules of grammar, it will provide the student with a vocabulary of several thousand words which not only enables him or her to speak fluently, and rarely be at a loss, but also to pick up the average Russian book or newspaper confident that most of it can be understood.

It has been ascertained that a beginner can memorize 10-20 new words of a foreign language in an hour; after a few hours' practice, it should be possible to memorize up to fifty new words per day. Thus, the Essential Vocabulary of Russian may be assimilated in about three months.

Know the Vocabulary Both Ways—
the English for each Russian word, and the Russian for each English one.

DAYS OF THE WEEK, MONTHS, etc.

TIME.

Minute, **мину́та** (—ы, —ы)
Hour, **час** (—а, —ы́)
Day, **день** (**дня, дни**) (masc.)
Week, **неде́ля** (—и, —и)
Month, **ме́сяц** (—а, —ы)
Year, **год** (—а, —ы and —а́)

SEASONS.

Spring, **весна́** (-ы́, -ы)
Summer, **ле́то** (-а, -а)
Autumn, **о́сень** (-и, -и) (fem.)
Winter, **зима́** (-ы́, -ы)

DAYS OF THE WEEK.

Sunday, **Воскресе́нье** (-я, -я)
Monday, **Понеде́льник** (-а, -и)
Tuesday, **Вто́рник** (-а, -и)
Wednesday, **Среда́** (-ы́, -ы)
Thursday, **Четве́рг** (-а́, -и́)
Friday, **Пя́тница** (-ы, -ы)
Saturday, **Суббо́та** (-ы, -ы)

MONTHS OF THE YEAR.

January, **Янва́рь** (-я́)
February, **Февра́ль** (-я́)
March, **Март** (-а)
April, **Апре́ль** (-я)
May, **Май** (-я)
June, **Ию́нь** (-я)
July, **Ию́ль** (-я)
August, **А́вгуст** (-а)

September, Сентя́брь (–я́)	November, Ноя́брь (–я́)
October, Октя́брь (–я́)	December, Дека́брь (–я́)

The names of the months are all masculine.

(The letters in brackets indicate the genitive singular and nominative plural. These words are all declined like nouns with corresponding endings.)

PROPER NAMES

NAMES OF COUNTRIES.

U.S.S.R. (Uníon of Soviet Socialist Republics).	С.С.С.Р. Союз Сове́тских Социалисти́ческих Респу́блик.
Russia,	Росси́я.
England,	А́нглия.
Great Britian,	Великобрита́ния.
France,	Фра́нция.
Germany,	Герма́ния.
Italy,	Ита́лия.
Greece,	Гре́ция.
Turkey,	Ту́рция.
United State of America,	Соединённые Шта́ты Аме́рики.
China,	Кита́й.
Japan,	Япо́ния.
Belgium,	Бе́льгия.
Spain,	Испа́ния.

NATIONALITY.

Adjectives	*Nouns*
Russian, Ру́сский	Ру́сский (-кая). (чанка).
English, А́нгли́йский	Англича́нин, Englishman
French, Францу́зский	Францу́з, Frenchman,
German, Неме́цкий	Не́мец, etc.
Italian, Италья́нский	Италья́нец
Amercian, Америка́нский	Америка́нец
Chinese, Кита́йский	Кита́ец
Japanese, Япо́нский	Япо́нец
Spanish, Испа́нский	Испа́нец
Turkish, Туре́цкий	Ту́рок
Greek, Гре́ческий	Грек

NAMES OF SOME IMPORTANT U.S.S.R. *INSTITUTIONS.*

АГИ́ТОТДЕЛ (Агитацио́нно-пропаганди́стский Отде́л), Agitation and Propaganda Dept.

БЮРОБИ́Н (Бюро по обслу́живанию иностра́нцев), Office for Assisting foreigners.

ВОКС (Всесою́зное О́бщество культу́рной свя́зи с грани́цей), All Union Society for Cultural Relations with foreign countries.

ГИЗ (Госуда́рственное Книгоизда́тельство), State Publishing House.

NOTE. As will be seen from the above, there is a tendency in the U.S.S.R. to 'telescope' the sometimes long names of state institutions into short words. There are hundreds of such words or abbreviations, of which the following may be found useful.

ВСНХ, Supreme Economic Council.

ВЦИК, All Union Central Executive Committee of Soviets.

ВЦСПС, All Union Central Council of Trade Unions.

ЗАВ (Заве́дывающий), A manager, chief, head.

ЗАВКО́НТ, Office Manager. **ГОСБА́НК**, State Bank.

КОЛХО́З, Collective farm.

КОМ, A committee or commission; also a Commissar or Commander.

КОМИНТЕ́РН, Communist (Third) International.

НАРБА́НК, People's Bank.

НАРКО́М, People's Commissar.

НАРСУ́Д, People's Court.

НЭП, New Economic Policy.

О́РА, All—Russian Union of Workers Associations.

ПОЛПРЕ́ДСТВО, Embassy of the USSR.

РАЙ, Used as a prefix for 'regional' (Райо́нный) Райсове́т, Regional Council.

РКП, Russian Communist Party.

РОСКОМБА́НК, Russian Commercial Bank.

РСФСР, Russian Socialist Federal Soviet Republic.

СНК, Council of People's Commissars.

СОВ, Used as a prefix for Сове́т (Soviet), Совработник, a Soviet worker.

СОВХО́З, Soviet state farm.

SOME COMMON EXPRESSIONS AND IDIOMS.

Я иностра́нец. I am a foreigner.

Моё и́мя . . . . (Джонс). My name is . . . . (Jones).

Я живу́ в . . . . I live at . . . .

Я встреча́ю затрудне́ние в . . . . I ám having difficulty in . . .

Как вы называ́ете э́то по русски? What do you call this in Russian?

Здра́вствуйте (or **до́брое у́тро, до́брый де́нь**). Good morning, good afternoon,

До́брый ве́чер, споко́йной но́чи. Good evening, good night.

Как вы пожива́ете? Хорошо́. How are you? Well.

Спаси́бо (благодарю́ Вас). Большо́е спаси́бо. I thank you. Many thanks.

Прости́те, пожа́луйста. Извини́те. I beg your pardon. Excuse me.

Пожа́луйста. If you please.

Это нева́жно. That does not matter.

Бу́дьте добры́ (or **любе́зны**) **помо́чь мне.** Would you kindly help me.

Покажи́те мне, пожа́луйста. Kindly show me.

Заходи́те (if on foot), **заезжа́йте** (if not on foot), **за мно́ю . . .** Fetch me . . .

Како́й курс на фунты́ сего́дня? What is the rate of exchange for pounds to-day ?

Я ничего́ не могу́ поделать. I cannot help it.

Я о́чень тороплю́сь. I am in a great hurry.

Где я мог бы разменя́ть а́нглийские де́ньги? Where can I get English money changed?

Хорошо́, ла́дно. All right.

Ско́лько . . .? (or **ско́лько сто́ит . . .?**) How much is . . .?

LESSON EIGHT

The Essential Vocabulary

In the list which follows some Russian words are printed in large letters. This indicates that they are important, and should be mastered first.

The letters in brackets after each noun indicate the Genitive Singular and Nominative Plural, which should always be learnt with the noun. Personal pronouns, numerals, days of the week, and months are given in Lessons 4 and 7.

А, а.

Абсолю́тный	Absolute, utter, sheer
Аво́сь	Perhaps, may be
Автомати́ческий	Automatic
АВТОМОБИ́ЛЬ	Automobile, motor-car
Автоно́мия (и, и)	Autonomy, independence
АВТОРИТЕ́Т (а, ы)	Authority
А́втор (а, ы)	Author
Аге́нт (а, ы)	Agent, representative
Адвока́т (а, ы)	Advocate, lawyer
Администра́ция (и, и)	Administration
А́ДРЕС(а, а́)	Address
Ад (а)	Hell
А́збука (и, и)	Alphabet
Актёр (а, ы)	Actor
Акти́в (а, ы)	Assets
Акт (а, ы)	Deed(document)
А́кция (и, и)	The share (business)
Акционе́р (а, ы)	Shareholder
Алле́я (и, и)	Avenue, drive
Алма́з (а, ы)	Diamond
Амба́р (а, ы)	Warehouse, barn
Апелли́ровать	To appeal
АПЕЛЬСИ́Н (а, ы)	Orange
Аппара́т (а, ы)	Apparatus
АППЕТИ́Т (а, ы)	Appetite
АПТЕ́КА (и, и)	Chemist's shop
АРГУМЕ́НТ (а, ы)	Argument
Аре́нда (ы, ы)	Lease
Аре́ст (а, ы)	Arrest, attachment
Арифме́тика (и, и)	Arithmetic
А́рка (и, и)	Arch
А́РМИЯ (и, и)	Army
АРТИ́СТ (а, ы)	Artist (actor)
Архите́ктор (а, а́)	Architect
Ассоциа́ция (и, и)	Association
Ата́ка (и, и)	Attack
Атакова́ть	To attack
Аукцио́н (а, ы)	Auction

Б, б.

Ба́ба (ы, ы)	Peasant (woman)
Ба́бушка (и, и)	Grandmother
БАЗА́Р (а, ы)	Bazaar, market
БА́ЗИС (а, ы)	Basis
Бала́нс (а, ы)	Balance (at bank)
БА́НКА (и, и)	Pot, jar
Банкро́т (а, ы)	Bankrupt
БАНК (а, и)	Bank
Ба́ня (и, и)	Bath-house
БА́РЫШНЯ (и, и)	Miss, young lady
Ба́рхат (а, ы)	Velvet
Ба́сня (и, и)	Fable
БАШМА́К (а́, и́)	Shoe
Бег (а, а́)	Course
БЕ́ГАТЬ[1]	To run
БЕ́ГСТВО (а)	The flight
БЕДА́ (ы́, ы)	Misfortune
БЕ́ДНЫЙ	Poor
БЕДРО́ (а́, бе̂дра)	Hip
Бежа́ть[2]	To run
Безнака́занность (и, и)	Impunity
БЕЗУ́МНЫЙ	Silly, mad
БЕЗ	Without (-less)
БЕ́ЛЫЙ	White
Бельê (я́), no plural	Linen (personal)
БЕ́РЕГ (а, а́)	Shore, coast
БЕРЕ́ЧЬ	To guard
БЕС (а, ы)	Devil
БЕСЕ́ДА (ы, ы)	Conversation
БЕСПОКО́ИТЬ	To trouble
БЕСПОЛЕ́ЗНЫЙ	Useless
БИБЛИОТЕ́КА (и, и)	Library
БИЛЕ́Т (а, ы)	Ticket
Би́тва (ы, ы)	Battle
БИТЬ	To strike, beat
БЛА́ГО (а, а́)	Good, welfare
БЛАГОДАРИ́ТЬ	To thank
БЛАГОДА́РНОСТЬ (и, и)	Thanks, gratitude
Благода́рный	Grateful
Благоприя́тный	Favourable
Благоро́дный	Gentle, noble
Благослове́ние (я, я)	Blessing
Благословля́ть	To bless
БЛЕ́ДНЫЙ	Pale
Блесте́ть	To shine
БЛИ́ЗКИЙ	Near
БЛЮ́ДО (а, а́)	Dish
БОГ (а. и)	God
БОГА́ТЫЙ	Wealthy
БОГА́ТСТВО (а, а)	Wealth
БО́ДРСТВОВАТЬ	To be awake
Бой (я. й)	Battle
Бо́йкий	Clever, smart
БОК (а, а́)	Side
Боло́то (а, а)	Marsh, swamp
БОЛЬ (и, и)	Pain
Больни́ца (ы, ы)	Hospital
БОЛЬНО́Й	Ill, sick
БОЛЬШИНСТВО́ (а́, а́)	Majority
БОЛЬШО́Й	Large, big
БО́ЛЬШЕ ВСЕГО́	Most
БОЛЕ́ЗНЬ (и, и)	Sickness, disease
Боле́зненный	Sore, ailing
БОЛЕ́ТЬ	To be ill
Борода́ (ы́, ы)	Beard
Борт (а́, ы́)	Side (of a ship)
БОРЬБА́ (ы́)	Struggle
Бо́чка (и, и)	Barrel
БОЯ́ТЬСЯ	To fear
БРА́К (а, и)	Marriage
БРАНИ́ТЬ	To blame, abuse
БРАТ (а, ья)	Brother
БРАТЬ	To take
Брить, Бри́ться	To shave
Бри́тва (ы, ы)	Razor

Бровь́ (и, и)	Eyebrow
Брод (а, ы)	Ford
Броди́ть	To wander
БРОСА́ТЬ	To throw
Броса́ться	To rush
Брошю́ра (ы, ы)	Pamphlet
БРЮ́КИ	Trousers
Буди́ть	To wake up
БУ́ДУЩИЙ	Future
Бу́ква (ы, ы)	Letter (alphabet)
Буке́т (а, ы)	Bouquet
БУЛА́ВКА (и, и)	Pin
БУ́ЛОЧНИК (а, и)	Baker
БУМА́ГА (и, и)	Paper
БУ́РЯ (и, и)	Storm
БУТЫ́ЛКА (и, и)	Bottle
Бу́хта (ы, ы)	Bay
БЫ́ВШИЙ	Former
БЫК (á, и́)	Bull
БЫ́СТРЫЙ	Swift, Rapid
БЫТЬ	To be
Бюро́ (not declined)	Office, bureau

В, в.

ВАГО́Н (а, ы)	Railway carriage
ВА́ЖНЫЙ	Important
ВА́ЖНОСТЬ (и) no plural	Importance
Ва́кса (ы) no plural	Boot-polish
Ва́нна (ы, ы)	Bath
ВАШ	Your
ВБЛИЗИ́	Near
ВВЕРХ	Upwards
Вверху́	Up, above
Ввози́ть	To import
Вдали́	Off, far
ВДВО́Е	Twice
ВДОВА́ (ы́, ы)	Widow
ВДО́ВОЛЬ	Enough, plenty
ВДОЛЬ	Along
ВЕДРО́ (á, вёдра)	The bucket

Вдохнове́ние (я, я)	Inspiration
Великоле́пный	Splendid
ВЕЗДЕ́	Everywhere
Везти́	To convey
ВЕК (а, á)	Century
Ве́ксель (я, я́)	Bill of exchange
ВЕЛИ́КИЙ	Great
ВЕ́РА (ы, ы)	Belief, faith
Верёвка (и, и)	String
Ве́рить	To believe, trust
Ве́рный	Faithful
ВЕРОЯ́ТНЫЙ	Probable
ВЕРТЕ́ТЬ	To turn
ВЕ́РХНИЙ	Upper
ВЕС (а, á)	Weight
Весёлый	Gay, merry
Ве́сить	To weigh
Весло́ (á, вёсла)	Oar
Вести́	To lead
Весы́ (plural о́в)	Scales (weighing)
ВЕСЬ	All
Ветвь (и, и)	Branch
ВЕ́ТЕР (тра, тра́)	Wind
Ветчина́ (ы́)	Ham
ВЕ́ЧЕР (а, á)	Evening
ВЕЩЬ (и, и)	Thing, object
Вещество́ (á, á),	Stuff, substance
Веще́ственный	Material (adj.)
ВЗАД	Back, backwards
ВЗГЛЯД (а, ы)	View, opinion
Взор (а, ы)	Look
Взя́тка (и, и)	Bribe
Взыва́ть	To appeal
ВИД (а, ы)	Appearance
Вибра́ция (и, и)	Vibration
ВИ́ДЕТЬ	To see
ВИЗИ́Т (а, ы)	Visit
ВИ́ЛКА (и, и)	Fork
Вина́ (ы́, ы)	Fault
Вино́ (á, а)	Wine
Винова́тый	Guilty

Винт (á, ы́)	The screw
Висе́ть	To hang
Висо́к (ска́, ски́)	Temple (head)
Вклад (а, ы)	Deposit (in a bank)
Включа́ть	To include
ВКУС (а, ы)	Taste
Владе́лец (а, ы)	Proprietor
ВЛАДЕ́ТЬ	To possess
ВЛАСТЬ (и, и)	Power, authority
Влия́ние (я, я)	Influence
Влия́ть	To affect
ВМЕ́СТЕ	Together
ВМЕ́СТО	Instead
ВНЕЗА́ПНЫЙ	Sudden
ВНЕ	Outside
ВНИЗУ́	Below, downstairs
ВНИЗ	Down, downwards
ВНИМА́НИЕ (я)	Attention
ВНОВЬ	Again
ВНУТРИ́	Inside, within
Внуша́ть	To suggest
Внуше́ние (я, я)	Suggestion
ВОДА́ (ы́. ы)	Water
Води́ть	To lead
ВОЖДЬ (я́, и́)	Chief, leader
Возбужда́ть	To excite, arouse
ВОЗВРА́Т (а, ы)	Return
Возвыша́ть	To raise
Возде́лывать	To cultivate (soil)
ВО́ЗДУХ (а, и)	Air
ВОЗИ́ТЬ	To carry, transport
ВО́ЗЛЕ	Beside, near
Возобновля́ть	To renew
ВОЗМО́ЖНЫЙ	Possible
ВО́ЗРАСТ (а, ы)	Age
ВОЙНА́ (ы́, ы)	War
ВО́ЙСКО (а, á)	Army, troops
ВОКРУ́Г	Around
Вол (á, ы́)	Ox, bull
Волк (а, и)	Wolf

NOTE. ¹˒². The verb 'to run' appears twice in page 526, once the perfective and once imperfective aspect. It will be seen in this and later pages that sometimes one, sometimes the other and sometimes both, are found in this Vocabulary. The student should assume that the aspect given is the more commonly used. Verbs with more than two aspects, or irregular, will be found on pages 518–519.

Волна́ (ы́, ы)	Wave
Во́лос (а, ы and а́)	Hair
Вообража́ть	To imagine
ВОПРО́С (а, ы)	Question
ВОР (а, ы)	Thief
ВОРОТА́ (plural)	Gate
ВОРОТНИ́К (а́, и́)	Collar
Воск (а)	Wax
Воскреса́ть	To arise
Воспита́ние (я)	Education, upbringing
Воспи́танник (а, и)	Pupil
ВОСТО́К (а)	The East
Восто́чный	Eastern, oriental
Воти́ровать	To vote
ВПЕРЕДИ́	Before, in front
ВПЕРЁД	Forward, forth
Впечатле́ние (я, я)	Impression
ВПОЛНЕ́	Completely
ВПРА́ВДУ	Really, truly
Впредь	Henceforth
ВПРО́ЧЕМ	Besides
ВРАГ (а́, и́)	Enemy
Вражда́ (ы́, no plural)	Hostility
Врать	To tell lies
ВРАЧ (а́, и́)	Physician
ВРЕД (а́, no plural)	Harm, injury
Вреди́ть	To hurt, injure
ВРЕ́МЯ (ени, ена́)	Time
Вруча́ть	To hand over
ВСЁ	All, everything
ВСЕГДА́	Always
ВСЕМИ́РНЫЙ	Universal
ВСЕЦЕ́ЛО	Entirely
ВСЕЦЕ́ЛЬНЫЙ	Entire
ВСКО́РЕ	Soon
ВСЛУХ	Aloud
ВСТАВА́ТЬ	To get up
Встреча́ть	To meet
Вступа́ть	To enter

ВСЮ́ДУ	Everywhere
ВСЯ́КИЙ	Every, each, everybody
Втече́ние	During
Входи́ть	To go in, enter
ВЧЕРА́	Yesterday
В, ВО	In, to
ВЫ	You
Выбира́ть	To select, to choose
ВЫ́БОР (а, ы)	Choice
Вы́боры (plural)	The elections
ВЫ́ВОЗ (а, ы)	Export
ВЫ́ГОДА (ы, ы)	Profit, advantage
Выздора́вливать	To recover
Выи́грывать	To win, gain
Вы́игрыш (а, и)	Gain (n.)
Вымога́ть	To extort
Выполня́ть	To fulfil
Вы́пуск (а, и)	The issue
Выража́ть	To express, utter
ВЫСО́КИЙ	High, tall
ВЫСОТА́ (ы, ы)	Height
Вы́ставка (и, и)	Exhibition
Вы́стрел (а, ы)	The shot
Высу́шивать	To drain, dry up
Выть	To weep, howl
Вы́сший	Supreme
Вытя́гивать	To extend
Вычёркивать	To cancel
Вычисля́ть	To calculate
ВЫШИНА́ (ы́)	Height
Выясня́ть	To explain
Вяза́ть	To bind, knit

Г, г.

ГА́ВАНЬ (и, и)	Port, harbour
ГАЗЕ́ТА (ы, ы)	Newspaper
Газ (а, ы)	Gas
Гармо́ния (и, и)	Harmony
Гвоздь (я́, и)	Nail, peg
ГДЕ	Where
ГДЕ́-БЫ ТО НИ́ БЫЛО	Anywhere

Генера́л (а, ы)	General
Геро́й (я, и)	Hero
ГЛАВА́ (ы́, ы)	Chapter, chief
ГЛА́ВНЫЙ	Main, principal
Глаго́л (а, ы)	Verb
Гла́дкий	Smooth
ГЛАЗ (а, а́)	Eye
Гли́на (ы, ы)	Clay
Глота́ть	To swallow
Глубина́ (ы́, ы)	Depth
ГЛУБО́КИЙ	Deep
ГЛУ́ПЫЙ	Foolish
ГЛУХО́Й	Deaf
ГЛЯДЕ́ТЬ	To look
Гнить	To rot
ГНЕ́В (а)	Anger
ГОВОРИ́ТЬ	To speak
Говори́ть по телефо́ну	To telephone
ГОВЯ́ДИНА (ы)	Beef
ГОД (а, ы or а́)	Year
ГОДОВО́Й	Annual, yearly
ГОЛОВА́ (ы́, ы)	Head
ГО́ЛОД (а)	Hunger, famine
ГО́ЛОС (а, а́)	Voice, vote
Го́лый	Naked
Гонора́р (а, ы)	Fee
Гора́ (ы́, ы)	Mountain
Горб (а́, ы́)	Hump
Го́рдый	Proud
ГО́РДОСТЬ	Pride
ГО́РЕ (я, no plural)	Sorrow
ГО́РЛО (а, а)	Throat
ГО́РОД (а, а́)	Town, city
Горожа́нин (а, а́не)	Townsman
Горчи́ца (ы)	Mustard
ГОРШО́К (шка́, и́)	Pot
Го́рький	Bitter
ГОСПОДИ́Н (а, да́)	Gentleman, Mr.
Го́спиталь (я, я́)	Hospital
ГОСПОЖА́ (и́, и́)	Lady. Mrs.

Гость (я, и)	Guest
Гости́нница (ы, ы)	Hotel, inn
Гото́вить	To prepare
ГОТО́ВЫЙ	Ready
Град (а)	Hail, hailstone
Гра́дус (а, ы)	Degree
ГРАЖДАНИ́Н (а, ане)	Citizen
Грамма́тика (и, и)	Grammar
ГРАНИ́ЦА (ы, ы)	Frontier
ЗАГРАНИ́ЦЕЙ	Abroad
Гра́ция (и, и)	Grace, charm
Гра́фство (а, а)	County
Гре́бень (бня, и)	Comb (n.)
Гребешёк (шка́, и́)	
Грести́	To row
Греть	To warm
Грех (а́, и́)	Sin
Гриб (а́, ы́)	Mushroom
Гроб (а, ы)	Coffin
ГРО́МКИЙ	Loud
ГРОМ (а, ы)	Thunder
ГРУДЬ (и́, и)	Breast
Груз (а, ы)	Freight, cargo
Грузи́ть	To load
Гру́ппа (ы, ы)	Group
ГРУСТЬ (и)	Sadness
Гру́стный	Sad
Гру́ша (и, и)	Pear
ГРЯЗЬ (и, и)	Dirt, mud
Гря́зный	Dirty
Губа́ (ы́, ы)	Lip
Гу́бка (и, и)	The sponge
ГУСТО́Й	Thick
Гусь (я, и)	Goose

Д, д.

Да	Yes
ДАВА́ТЬ	Give, grant
Дави́ть	To press, crush
ДАВНО́	Long ago
ДА́ЖЕ	Even
ДАЛЁКИЙ	Far, distant
И ТАК ДА́ЛЕЕ (И.Т.Д.)	Et cetera (etc.)
ДАЛЬ (и, и)	Distance
ДА́ЛЕЕ	Further
ДА́МА (ы, ы)	Lady
ДАР (а, ы́)	Gift, present
ДВЕРЬ (и, и)	Door
ДВИ́ГАТЬ (—ся)	To move
ДВИЖЕ́НИЕ (я, я)	Movement, motion
ДВОР (а́, ы́)	Court, yard
Двоя́кий	Double, twofold
ДЕ́ВА (ы, ы)	Maid
ДЕ́ВОЧКА (и, и)	Girl (child)
Де́вушка	Young girl
ДЕЙСТВИ́ТЕЛЬНЫЙ	Real, actual
ДЕЙСТВИ́ТЕЛЬНО	Indeed, really
ДЕ́ЙСТВИЕ (я, я)	Action
ДЕ́ЙСТВОВАТЬ	To act, to operate
ДЕ́ЛАТЬ	To do, to make
Делика́тный	Delicate
ДЕ́ЛО (а, а́)	Work, business
ДЕ́НЬГИ (plural)	Money
ДЕНЬ (дня, дни)	Day
Департа́мент (а, ы)	Department
Депе́ша (и, и)	Despatch, telegram
Депо́зит (а, ы)	The deposit
Де́рево (а, вья)	Tree
ДЕРЖА́ТЬ	To hold, to keep
Дерза́ть	To dare
Десе́рт (а, ы)	Dessert
Дета́ли	Details (pl.)
ДЕШЁВЫЙ	Cheap
Де́ятельный	Active
Ди́кий	Wild
Диктова́ть	To dictate
Диплома́т (а, ы)	Diplomat
ДИТЯ́ (—тя́ти, де́ти)	Child
Дичь (и)	Game (bird, etc.)
Длина́ (ы́, ы)	Length
Дли́нный	Long
ДЛЯ	For
ДНО (а, до́нья)	Bottom
ДО	Till, until
Добавля́ть	To add
Добавле́ние (я, я)	Addition
Доброде́тель (и, и)	Virtue
Доброта́ (ы́)	Kindness, goodness
ДО́БРЫЙ	Good, kind
Добыва́ть	To earn, win
Дове́ренность (и, и)	Power of attorney
Дове́рие (я)	Confidence
Доверя́ть	To trust
Доверша́ть	To complete
До́вод (а, ы)	An argument
Дово́льно	Sufficient, enough
Дово́льный	Content
ДОГОВО́Р (а, ы)	Agreement, contract
ДОЖДЬ (я́, и́)	Rain
Дои́ть	To milk
Доказа́тельство (а, а)	The proof
Дока́зывать	To prove
ДОКА́НЧИВАТЬ	To finish (off,
ДОКЛА́Д (а, ы)	Report
Доложи́ть	To announce, to report
ДО́КТОР (а, а́)	Doctor
ДО́ЛГИЙ	Long
ДОЛГ (а, и́)	Debt, duty
Долженствова́ть	Must, have a duty to
Должни́к (а́, и́)	Debtor
До́лжный	Due
Доли́на (ы, ы)	Valley
До́лла́р (а, ы)	Dollar
ДОЛО́Й	Away, down (with)
До́ля (и, и)	Share, part
ДОМ (а, а́)	House, home
Дома́шний	Domestic
ДОНЫ́НЕ	Till now
Допра́шивать	To question, examine
Допро́с (а, ы)	Examination, questioning
ДОПУСКА́ТЬ	To admit, allow
ДОРО́ГА (и, и)	Way, route, road
ДОРОГО́Й	Dear, expensive
Доса́да (ы, ы)	The spite, vexation
Доска́ (и́, и)	Board
ДОСТАВА́ТЬ	To procure, to obtain

Доставля́ть	To afford, deliver, supply
Доста́точный	Sufficient
Достига́ть	To reach
ДОСТО́ИНСТВО (а)	Worth, dignity
Досто́йный	Worthy
Дохо́д (а, ы)	Income
ДОЧЬ (—чери, чери)	Daughter
Драгоце́нность (и, и)	Jewel
Драгоце́нный	Precious
Дрожа́ть	To shiver
ДРУГО́Й	Other, another
ДРУГ (а, —зья́)	Friend
ДРУ́ЖБА (ы)	Friendship
Дружелю́бный	Kindly
Дру́жеский	Friendly
ДУ́МАТЬ	To think
Дуб (а, ы́)	Oak
Дура́к (а́, и́)	The fool
ДУРНО́Й	Bad
Дуть	To blow
Дух (а, и)	Spirit
Духи́ (plural)	Perfume
ДЫМ (а, ы́)	The smoke
Дыра́ (ы́, ы)	Hole
ДЫХА́НИЕ (я)	Breath
Дья́вол (а, ы)	Devil
ДЮ́ЖИНА (ы, ы)	Dozen
Дюйм (а, ы)	The inch
ДЯ́ДЯ (и, и or ья́)	Uncle

Е, е.

ЕДВА́	Hardly
Едини́ца (ы, ы)	Unity
Еди́нственный	Only, sole
ЕДИ́НЫЙ	One, single
ЕЖЕДНЕ́ВНО	Daily, every day
Езда́ (ы́)	The ride
Е́здить	To travel, ride
Е́СЛИ	If
Есте́ственный	Natural
Есть	To eat
ЕЩЁ	Still, more, yet

Ж, ж.

ЖА́ЖДА (ы)	Thirst
Жа́лоба (ы, ы)	Complaint
ЖА́ЛОВАНЬЕ (я, я)	Wages, pay
ЖА́ЛОСТЬ (и)	Pity
ЖАЛЕ́ТЬ	To regret
ЖАРА́ (ы́, ы́)	Heat
ЖА́ТВА (ы, ы)	Crop, harvest
ЖДА́ТЬ	To wait, expect
ЖЕЛА́НЬЕ (я, я)	Wish, desire
Жела́ющий	Willing
ЖЕЛА́ТЬ	To desire, to wish
ЖЁЛТЫЙ	Yellow
ЖЕЛЕ́ЗНАЯ ДОРО́ГА	The railway
ЖЕЛУ́ДОК (а, и)	Stomach
ЖЕЛЕ́ЗО (а)	Iron
ЖЕ́НЩИНА (ы, ы)	Woman
ЖЕНА́ (ы, жёны)	Wife
ЖЕНИ́ТЬСЯ	To marry a wife
ЖЕНИ́ТЬБА (ы, ы)	Marriage, wedding
ЖЕ́НСКИЙ	Female
Же́ртва (ы, ы)	Sacrifice
ЖЁСТКИЙ	Hard
ЖЕСТО́КИЙ	Cruel
ЖЕЧЬ	To burn
Живопи́сец (сца, ы)	Painter, artist
ЖИВО́ТНОЕ (ого, ые)	Animal
Жи́вость (и)	Vivacity, liveliness
ЖИВЬЁМ	Alive
ЖИ́ДКИЙ	Liquid
ЖИЗНЬ (и, и)	Life
ЖИР (а, ы́)	Fat (n.)
Жи́рный	Fat (adj.)
ЖИТЬ	To live
Жре́бий (я, и)	Lot, allotment
ЖУРНА́Л (а, ы)	Journal, magazine

З, з.

ЗА	For
Заба́ва (ы, ы)	Amusement, fun
Забавля́ть	To amuse
Забасто́вка (и, и)	Strike (of workmen)
Забо́р (а, ы)	Fence
ЗАБО́ТА (ы, ы)	Care, trouble
ЗАБЫВА́ТЬ	To forget
Зави́довать	To envy
Зави́симость	Dependence
ЗАВИ́СЕТЬ	To depend
За́висть (и)	Jealousy
ЗАВО́Д (а, ы)	Factory, works
Завоева́ние (я, я)	Conquest
Завоёвывать	To conquer
ЗА́ВТРАК (а, и)	Breakfast, lunch
ЗА́ВТРА	To-morrow
ЗА́ВТРАКАТЬ	To lunch, breakfast
Заве́дывать	To manage
Заве́са (ы, ы)	Curtain
ЗАВЕЩА́НИЕ (я, я)	Will, testament
Загла́вие (я, я)	Title (of book)
Загово́р (а, ы)	Conspiracy
Загора́живать	To enclose fence
ЗАДА́ЧА (и, и)	Task, problem
ЗАДЕ́РЖИВАТЬ	To detain, retain
Задуше́вный	Cordial, hearty
ЗАЁМ (йма, ы)	Loan
Зака́з (а, ы)	Order (of goods)
Заключа́ть	To conclude, decide
Заключе́ние (я, я)	Conclusion
ЗАКО́Н (а, ы)	Law
Закочене́лый	Stiff, numb
ЗАКРЫВА́ТЬ	To shut
Зал (а, ы)	Hall
Зали́в (а, ы)	Gulf
Зало́г (а, и)	Pledge, mortgage
ЗАМО́К (мка, и́)	Lock (n.)
ЗАМЕСТИ́ТЕЛЬ (я, и)	The substitute
Заме́тка (и, и)	Mark, note
ЗАМЕ́ТИТЬ	To mark, observe
Замеша́тельство (а, а)	Confusion
За́навес (а, ы)	Curtain
ЗАНИМА́ТЬ	To occupy

Занима́ть (де́ньги)	To borrow
ЗАНЯ́ТИЕ (я, я)	Business, job
ЗА̀НЯТЫЙ	Busy
ЗА́ПАД (а)	The West
За́падный	Western
ЗАПА́С (а, ы)	Store, stock
За́пах (а, и)	Smell, scent
Запи́сывать	To record
ЗАПРЕЩА́ТЬ	To prohibit
ЗАРА́НЕЕ	Beforehand
ЗАРЯ́ (и, зо́ри)	Dawn
Заряжа́ть	To load (weapons)
ЗАСЛУ́ГА (и, и)	Merit
Заслу́живать	To deserve
Заседа́ние (я, я)	Session
ЗАТРУДНЕ́НИЕ (я, я)	Difficulty
ЗАЧЕ́М	Why
Защи́та (ы, ы)	Defence
Защища́ть	To defend, protect
ЗВАТЬ	To call, invite
ЗВЕЗДА́ (ы́, звёзды)	Star
Зверь (я, и)	Beast
ЗВУК (а, и)	Sound
Звуча́ть	To sound
ЗДЕСЬ	Here
ЗДОРО́ВАТЬСЯ	To greet
ЗДОРО́ВЬЕ (я)	Health
Здоро́вый	Healthy
ЗЕЛЁНЫЙ	Green
ЗЕМЛЯ́ (и́, и)	Earth
ЗЕМЛЕДЕ́ЛИЕ (я)	Agriculture
Зе́ркало (а, а́)	Mirror
Зерно́ (а́, зёрна)	Grain, corn
ЗИМА́ (ы́, ы)	Winter
ЗЛО (а)	Evil
Змея́ (и́, и)	Snake
Знак (а, и)	Sign, mark
ЗНАКО́МИТЬ	To acquaint
ЗНАКО́МСТВО	Acquaintance
ЗНА́МЯ (—мени, мёна)	Standard
ЗНА́НИЕ (я, я)	Knowledge
ЗНАТЬ	To know
ЗНА́ЧИТЬ	To signify, mean
ЗО́ЛОТО (а)	Gold
Золото́й	Golden
Зо́нтик (а, и)	Umbrella
Зре́лище (а, а)	Spectacle, scene
Зре́ние (я)	Eye-sight
ЗУБ (а, ы)	Tooth

И, и.

И	And
И́БО	For, since, because
Игла́ (ы́, ы)	Needle
Игру́шка (и, и)	The toy
Игра́ (ы́, ы)	Game
Игра́ть	To play
ИДЕА́Л (а, ы)	The ideal
ИДЕ́Я (и, и)	Idea
ИЗБЕГА́ТЬ	To avoid, to escape
ИЗБИРА́ТЬ	To elect, to choose
ИЗБРА́НИЕ (я, я)	Election, choice
ИЗВЕЩА́ТЬ	To inform
ИЗВЕЩЕ́НИЕ (я, я)	Notification
Извине́ние (я, я)	Excuse, apology
ИЗВИНЯ́ТЬ	To excuse, forgive
ИЗВНЕ́	From outside
Издава́ть	Publish
ИЗЛАГА́ТЬ	To state
Излечи́ть	To heal, to cure
ИЗЛОЖЕ́НИЕ (я. я)	The statement
Излю́бленный	Favourite
Изме́на (ы, ы)	Treason
ИЗОБРАЖА́ТЬ	To represent
Изобрести́	To invent
Изобрета́тель (я, и)	Inventor
Изя́щество (а)	Grace, elegance
ИЗ	From
И́ЛИ	Or
ИМЕ́ТЬ	To have, possess
И́мпульс (а, ы)	The impulse
ИМУ́ЩЕСТВО (а, а)	Property
И́МЯ (и́мени. —а́)	Name
И́НАЧЕ[1]	Otherwise
ИНДИВИ́ДУУМ (а, ы)	Individual
ИНОГДА́	Sometimes
ИНО́Й	Other, another
Инста́нция (и, и)	Instance
ИНСТРУМЕ́НТ (а, ы]	Instrument, tool
Интере́с (а, ы)	Interest
Интернациона́льный	International
ИСКА́ТЬ	To seek, search
Исключа́ть	To exclude, except
Исключе́ние (я, я)	Exception
И́скра (ы, ы)	Spark
И́скренний	Sincere
ИСКУ́ССТВО (а, а)	Art
ИСПУ́ГАННЫЙ	Afraid
Испыта́ние (я, я)	The trial, examination
И́СТИНА (ы, ы)	Truth
И́СТИННЫЙ	True
ИСТО́РИЯ (и, и)	History
Исто́чник (а, и)	Source
Исхо́д (а, ы)	Issue, outcome
ИТО́Г (а. и)	Total
ИТТИ́	To go
ИСТОЩА́ТЬ	To waste, exhaust

К, к.

К (ко)	To, towards
Каба́н (а, ы)	The hog, wild boar
КА́ЖДЫЙ	Each, every
КАЗА́ТЬСЯ	To seem
КАК	How, as
КА́К—НИБУДЬ	Anyway
КА́МЕНЬ (мня, —и)	Stone
КА́МЕРА (ы, ы)	Camera (photo) chamber, cell
Кана́л (а, ы)	Canal
Ка́пать	To drop, drip

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[1] Also pronounced **ина́че**

Капитáл (а, ы)	Capital
Капитали́зм (а, ы)	Capitalism
Капитáн (а, ы)	Captain
КÁПЛЯ (и, и)	Drop (n.)
Карандáш (á, и́)	Pencil
Карéта (ы, ы)	Carriage, coach
КАРМÁН (а, ы)	Pocket
КÁРТА (ы, ы)	Card, map
КАРТИ́НА (ы, ы)	Picture
Картóфель (я)	Potatoes and potato
КАСÁТЬСЯ	To touch, concern
Кáсса (ы, ы)	Till, cash
КÁЧЕСТВО (а, а)	Quality
Кáшель (шля)	Cough
Кáшлять	To cough
КВАРТИ́РА (ы, ы)	Flat, apartment
Кипéть	To boil
Кирпи́ч (á, и́)	Brick
Ки́слый	Acid, sour
Кладби́ще (а, а)	Churchyard
КЛАСС (а, ы)	Class
КЛАСТЬ	To lay, put
Клéточка (и, и) (в сéти)	Mesh (also cell)
КЛИ́МАТ (а, ы)	Climate
Клиéнт (а, ы)	Client
Клони́ть	Bend, incline
Клуб (а, ы)	Club, club-house
КЛЮЧ (á, и́)	Key
КНИ́ГА (и, и)	Book
Ковёр (врá, ы́)	Carpet
Кóврик (а, и)	Rug
КОГДÁ	When
КÓЕ—ГДЕ	Somewhere
Кóжа (и, и)	Skin, leather
Козёл (злá, ы́)	The goat
КОЛИ́ЧЕСТВО (а, а)	Quantity
Колея́ (и́, и́)	The track
Коллѐгия (и, и)	College, collegium
КОЛЕСÓ (á, ёса)	The wheel
Колóдец (дца, —ы)	Well, spring
Колебáние (я, я)	Vibration, hesitation

Кóлокол (а, á)	Bell
Колéно (а, а)	Knee
Колóнна (ы, ы)	Column
Кольцó (á, а)	Ring
Комáр (á, ы́)	Gnat
Комéдия (и, и)	Comedy
Комéта (ы, ы)	Comet
Коммиссáр (а, ы)	Commissar
Комитéт (а, ы)	Committee
Коммерсáнт (а, ы)	Merchant
Коммéрческий	Commercial
КÓМНАТА (ы, ы)	Room
КОМПÁНИЯ (и, и)	Company, gathering
Конвéнция (и, и)	Convention
Конвéрт (а, ы)	Envelope
Конкурéнция (и, и)	Competition
КОНÉЦ (нцá, ы́)	End
Континéнт (а, ы)	Continent
Кóнсул (а, ы)	Consul
КОНТÓРА (ы, ы)	Office
Контóрка (и, и)	Desk (in office)
Контрáкт (а, ы)	Contract
Конфисковáть	Confiscate
Концéрт (а, ы)	Concert
КОНЧÁТЬ	To finish
КОНЬ (я́, и)	Horse
Копáть	To dig
КÓПИЯ (и, и)	Copy
КОРÁБЛЬ (я́, и́)	Ship
Кóрень (рня, рни)	Root
Корзи́на (ы, ы)	Basket
Кори́чневый	Brown
Корридóр (а, ы)	Corridor, passage
Корми́ть	To feed, nourish
Корóва (ы, ы)	Cow
Корóль (я́, и́)	King
Корóна (ы, ы)	Crown
КОРÓТКИЙ	Short, brief
КОСТЬ (и, и)	Bone
Костю́м (а, ы)	Costume, dress
Кот (á, ы́)	(He) cat
Котёл (тлá, ы́)	The kettle, boiler
КОТÓРЫЙ	Which
Кóфе (not declined)	Coffee
Кóшка (и, и)	(She) cat
Край (я, я́) (конéц)	Margin, tip
КРАЙ (странá)	Country, land

КРÁЙНИЙ	Extreme
КРАСИ́ВЫЙ	Handsome, pretty
Крáсить	To paint
КРÁСКА (и, и)	Colour, paint (n.)
КРÁСНЫЙ	Red
КРАСОТÁ (ы́, ы)	Beauty
Креди́т (а, ы)	Credit
Кредитóр (а, ы)	Creditor
КРÉПКИЙ	Firm, strong
Крест (á, ы́)	The cross
Крести́ть	To baptize
КРЕСТЬЯ́НИН (а, я́не)	Peasant
Крик (а, и)	Cry
КРИЧÁТЬ	To cry
КРОВÁТЬ (и, и)	Bed
Кровь (и, и)	Blood
КРÓМЕ	Except, besides
Крýжево (а, á)	Lace
КРУГ (а, и́)	Circle
Кружи́ть	To twist, to circle around
КРУ́ГЛЫЙ	Round
КРУ́ПНЫЙ	Big
Крушéние (я, я)	Accident, shipwreck
Кры́са (ы, ы)	Rat
Крыло (á, ья)	Wing
КРЫТЬ	To cover
Кры́ша (и, и)	Roof
Крюк (á, и́)	Hook
КТО	Who
КТÓ-ЛИБО	Somebody
КТÓ-НИБУДЬ	Anybody
КТÓ—ТО	Somebody
Кузéн (а, ы)	Cousin
Купéц (пцá, ы́)	Merchant
КУПИ́ТЬ	To purchase
Кýрица (ы, ры)	Hen
Курс (а, ы)	Course
Курс (дéнег)	Rate of exchange
КУСÓК (скá, и́)	Piece, bit, lump
Кусáть	To bite
Куст (á, ы́)	Bush

Куха́рка (и, и)	Cook (fem.)
Ку́хня (и, и)	Kitchen
Ку́ча (и, и)	Heap
КУ́ШАТЬ	To eat

Л, л.

ЛА́ВКА (и, и)	Shop
Ла́герь (я, я́)	Camp
Ла́зить	To climb
Ла́мпа (ы, ы)	Lamp
Ла́ять	To bark
Лгать	To tell lies
Ле́бедь (я, и)	Swan
Лев (льва́, ы́)	Lion
ЛЁГКИЙ	Light, easy
Лёд (льда́, ы́)	Ice
Ледени́ть	To freeze
Лежа́ть	To lie down
Ле́звие (я, я)	The blade
Ле́зть	To climb
Лека́рство, (а, а)	Medicine, drug
Ле́кция (и, и)	Lecture
ЛЕНИ́ВЫЙ	Lazy, idle
Ле́нта (ы, ы)	Ribbon, band
ЛЕС (а, а́)	Wood, forest
Ле́стница (ы, ы)	Staircase, ladder
ЛЕТА́ТЬ	To fly
Лже́-	Pseudo, false
ЛИ . . . ЛИ	Whether . . . or, either . . . or
Либера́льный	Liberal
ЛИ́БО	Or
Ли́вень (–вня, и)	The shower
Лимо́н (а, ы)	Lemon
Ли́ния (и, и)	Line
Лист (а́. ы́ or ья)	Leaf, sheet
Лить	To pour
Лихора́дка (и, и)	Fever
ЛИЦО́ (а́, а)	Face, person
ЛИ́ЧНОСТЬ (и, и)	Personality, person
ЛИ́ЧНЫЙ	Personal
ЛИШЬ	Only
Ло́вкий	Clever, skilled
Ло́дка (и, и)	Boat
Ло́жь (лжи, no plural)	Lie, falsehood
Ло́жка (и, и)	Spoon
Ло́жный	False, wrong
ЛОМА́ТЬ	To break
Ло́паться	To burst
Ло́шадь (и, и)	Horse
Лук	Onion
Лу́ковица (ы, ы)	The bulb
ЛУНА́ (ы́, ы)	Moon
Луч (а́, и́)	Beam, ray
ЛУ́ЧШЕ	Better
ЛУ́ЧШИЙ	Best
ЛЮБЕ́ЗНЫЙ	Kind, amiable
Люби́мый	Darling, beloved
ЛЮБИ́ТЬ	To love, like
Любова́ться	To admire
Любо́вник (а, и)	Lover
ЛЮБО́Й	Any
ЛЮ́ДИ (plural)	People, men

М, м.

МАГАЗИ́Н (а, ы)	Shop
МА́ЛЫЙ	Small
МА́ЛЕНЬКИЙ	Tiny
МА́ЛО	Little, few
МА́ЛЬЧИК (а, и)	Boy
Ма́ма (ы, ы)	Mama
Мануфакту́ра (ы, ы)	Manufacture (n.), manufactured goods
Мара́ть	To soil
МА́РКА (и, и)	Postage-stamp, trade mark
Ма́сло (а, а́)	Butter, oil
Ма́сса (ы, ы)	Mass, heap
Матери́к (а́, и́)	Continent
Материа́л (а, ы)	Material
Материа́льный	Material (adj.)
МАТЕ́РИЯ (и, и)	Matter
МАТЬ (ери, ери)	Mother
Ма́чта (ы, ы)	Mast
МАШИ́НА (ы, ы)	Machine, engine
МГНОВЕ́НИЕ (я, я)	Moment, instant
Ме́бель (и)	Furniture
Медве́дь (я, и)	Bear
МЕДИКАМЕ́НТ (а. ы)	Medicine (remedy)
МЕДИЦИ́НА	Medicine (science)
МЕ́ДЛИТЬ	To delay, linger
МЕ́ДЛЕННЫЙ	Slow
Мёд (а)	Honey
МЕДЬ (и)	Copper, brass
МЕ́ЖДУ	Between, among
МЕЖДУНАРО́ДНЫЙ	International
Ме́льница (ы. ы)	Mill
МЕ́НА (ы)	Exchange, barter
МЕ́НЬШЕ **МЕ́НЕЕ**	Less
МЕНЬШИНСТВО́ (а́, а́)	Minority
МЕНЯ́ТЬ	To change
МЕ́РА (ы, ы)	Measure
Мёрзнуть	To freeze, get frozen
МЕ́РИТЬ	To measure
МЁРТВЫЙ	Dead
МЕ́СТО (а, а́)	Place
Ме́стный	Local
Местоположе́ние (я, я)	Situation
МЕ́СЯЦ (а, а́ or ы)	Month, moon
МЕТА́ЛЛ (а, ы)	Metal
МЕ́ТОД (а, ы)	Method
МЕТР (а, ы)	Metre
Мех (а, а́)	Fur
МИГ (а, и)	Moment
МИЛЛИО́Н (а, ы)	Million
МИ́ЛЫЙ	Charming, lovely
Ми́ля (и, и)	Mile
Ми́на (ы, ы)	Mine (coal, etc.)
Минера́л (а, ы)	Mineral
Мини́стр (а, ы)	Minister
МИНУ́ТА (ы, ы)	Minute
МИР (а)	Peace
МИР (а, ы́) **МIРЪ**	World, universe

Младе́нец (нца, ы)	Baby
МНЕ́НИЕ (я, я)	Opinion
МНО́ГИЙ	Many
МНО́ГО	Plenty, much
МНОГОЧИ́СЛЕННЫЙ	Numerous
Моги́ла (ы, ы)	Grave (n.)
МОГУ́ЩЕСТВО (а)	Power
Мо́да (ы, ы)	Fashion
МО́ЖЕТ-БЫТЬ	Perhaps
Мозг (а, и́)	Brain
МО́КРЫЙ	Wet
Моли́тва (ы, ы)	Prayer
МОЛОДЁЖЬ (и)	Young people
Моли́ться	To pray
МОЛОДО́Й	Young
Мо́лодость (и)	Youth
МОЛОКО́ (а́)	Milk
Молото́к (тка́, и)	Hammer
Молчали́вый	Silent
МОЛЧА́НИЕ (я)	Silence
МОМЕ́НТ (а, ы)	Moment
МОНЕ́ТА (ы, ы)	Coin, money
Монуме́нт (а, ы)	Monument
МОРА́ЛЬ (и)	Morality
Мора́льный	Moral
МО́РЕ (я, я́)	Sea
Моро́з (а, ы)	Frost
МОСТ (а, ы́)	Bridge
МОТО́Р (а, ы)	Motor
Мочь	To be able
МОЩЬ (и)	Power, strength
МО́ЩНЫЙ	Powerful strong
Му́дрость (и)	Wisdom
МУ́ДРЫЙ	Wise
МУЖ (а́, ья́)*	Husband
МУ́ЖЕСТВЕННЫЙ	Brave
МУ́ЖЕСТВО (а)	Courage
МУЖИ́К, (а́, и́)	Peasant
МУЖСКО́Й	Male

* Вы́йти замуж—To marry a husband.

Му́зыка (и)	Music
Му́ка (и, и)	Torture
Мука́ (и́)	Meal, flour
Муравѐй (вья́, и́)	Ant
Му́ха (и, и)	Fly
МЫ́ЛО (а)	Soap
МЫСЛЬ (и, и)	Thought, idea
Мыть	To wash
Мя́гкий	Soft, tender
Мясни́к (а́, и́)	Butcher
Мя́со (а, а́)	Flesh, meat
Мяч (а́, и́)	Ball (for games)

Н, н.

НА	On, upon
НАБЛЮДА́ТЬ	To observe
НАВЕРХУ́	Above
НАВРЯ́Д	Hardly
На́вык (а, и)	Habit
НАВЕЩА́ТЬ	To visit
Наго́й	Bare, naked
Награ́да (ы, ы)	Reward
НАДЕ́ЖДА (ы, ы)	Hope
НАДЁЖНЫЙ	Sure, reliable
НАДЕ́ЯТЬСЯ	To hope
Надзо́р (а, ы)	Control, supervision
НАДЛЕЖА́ЩИЙ	Proper. due
НАД	Above
НАДОЕДА́ТЬ	To bother, to bore
НАЕДИНЕ́	Alone (with somebody)
НАЁМ (йма)	Hire, rent (n.)
НАЖИ́ВА (ы, ы)	Gain
НАЖИВА́ТЬ	To earn, gain, make money
НАЗАДИ́	Behind
НАЗА́Д	Back, backwards
Назва́ние (я, я)	Name, title
НАЗНАЧА́ТЬ	To determine, fix, nominate, appoint
НАЗЫВА́ТЬ	To name, call
НАИЛУ́ЧШИЙ	Best
НАИМЕ́НЬШИЙ	Least

Наказа́ние (я, я)	Punishment
НАКА́ЗЫВАТЬ	To punish
Нака́чивать	To pump
Накладна́я (о́й, ые)	Invoice
НАКОНЕ́Ц	At last, finally
Нало́г (а, и)	Tax, rate
НАМЁК (а, и)	Suggestion, hint
НАМЕ́РЕВА́ТЬСЯ	To intend
НАМЕ́РЕНИЕ (я, я)	Intention, purpose
НАМЕ́РЕННО	Intentionally, purposely
НАНИМА́ТЬ	To hire, engage
Напада́ть	To attack
Нападе́ние (я, я)	Attack, assault
Напереко́р	Contrary, despite
НАПИ́ТОК (-тка, и)	Drink (n.)
Напо́лнить	To fill
НАПОМИНА́ТЬ	To remind
НАПРАВЛЯ́ТЬ	To guide, direct
НАПРАВЛЕ́НИЕ (я, я)	Direction
НАПРО́ТИВ	Opposite, on the contrary
НАРО́Д (а, ы)	Folk, people, nation
НАРО́ДНЫЙ	Popular, people's
НАРУ́ЖНЫЙ	Exterior, external
НАРУША́ТЬ	To break, contravene
Наря́дный	Trim, neat, decked up
Населя́ть	To colonize, inhabit
НАСЕКО́МОЕ (ого, ые)	The insect
НАСЕЛЕ́НИЕ (я, я)	Population
Наси́лие (я, я)	Violence
НАСКВО́ЗЬ	Through and through
НАСКО́ЛЬКО	As far as, as much as
Наслажде́ние (я, я)	Delight
Насле́дник (а, и)	Heir
Насле́дственный	Hereditary
Насле́дство (а, а)	Heritage, succession
НАСТАВЛЯ́ТЬ	To instruct
НАСТАВЛЕ́НИЕ (я, я)	Instruction
НАСТА́ИВАТЬ	To insist
НАСТО́ЛЬКО	As much as

НАСТРОЕ́НИЕ (я, я)	Humour, mood
НАТУ́РА (ы, ы)	Nature
НАУ́КА (и, и)	Science
НАУ́ЧНЫЙ	Scientific
НАХОДИ́ТЬ	To find, discover
НА́ЦИЯ (и, и)	Nation
НАЦИОНА́ЛЬНЫЙ	National
НАЧА́ЛО (а, а)	Beginning
НАЧА́ЛЬНИК (а, и)	Chief, head
НАЧИНА́ТЬ	To begin, start
НЕ	Not
НЕ́БО (а, еса́)	Heaven, sky
Небре́жность (и, и)	Negligence
Неви́нность (и, и)	Innocence
НЕВОЗМО́ЖНЫЙ	Impossible
НЕ́ГДЕ	Nowhere
НЕДА́ВНИЙ	Recent
НЕДЕ́ЛЯ (и, и)	Week
НЕДОСТА́ТОК (тка, и)	Lack, deficiency
НЕ́ЖЕЛИ	Than
НЕ́КИЙ	One, some, a certain
НЕ́КОГДА	Once
НЕ́КОТОРЫЙ	Some, certain
НЕ́КТО	Someone
Нело́вкий	Awkward
НЕЛЬЗЯ́	One cannot, must not
НЕМНО́ГО	A little
Немо́й	Dumb
Ненави́деть	To hate
НЕОБХОДИ́МЫЙ	Necessary
Необы́чный	Unusual
НЕПОСРЕ́ДСТВЕННЫЙ	Immediate
НЕПРА́ВИЛЬНЫЙ	Wrong
НЕПРИЯ́ТЕЛЬ (я, и)	Enemy
Нерв (а, ы)	Nerve
НЕ́СКОЛЬКО	Several, a few
НЕСМОТРЯ́	In spite of
НЕСОМНЕ́ННО	Doubtless

НЕСПОСО́БНЫЙ	Unable, incapable
НЕСТИ́	To carry, bring
НЕСЧАСТЛИ́ВЫЙ НЕСЧА́СТНЫЙ	Unfortunate, unhappy
НЕТ	No, not, not any
НЕ́ЧТО	Something
НИ . . . НИ	Neither . . . nor
НИГДЕ́	Nowhere
НИ́ЖЕ	Below
НИ́ЖНИЙ	Low, lower
НИ́ЗКИЙ	Low
Ни́зкий (мора́льно)	Base, evil
НИКОГДА́	Never
НИКТО́	Nobody
Нить (и, и) Ни́тка (и, и)	Thread
НИЧТО́	Nothing, naught
НО	But
НО́ВОСТЬ (и, и)	News
НО́ВЫЙ	New
Нога́ (и́, и)	Leg, foot
Но́готь (гтя, и)	Nail (of finger or toe)
НОЖ (а́, и́)	Knife
Но́жницы (plural)	Scissors
НОРМА́ЛЬНЫЙ	Normal
Нос (а, ы́)	Nose
Носо́к (ска́, и́)	The sock, toe (of shoe, etc.)
НОСИ́ТЬ	To bear, wear
НОСИ́ЛЬЩИК	Porter
НО́ТА (ы, ы)	Note
НОЧЬ (и, и)	Night
НРАВ (а, ы)	Character
НУЖДА́ (ы́, ы)	Need, necessity
НУЖДА́ТЬСЯ	To want, need
НУ́ЖНЫЙ	Necessary
НУ́МЕР. (Но́мер, а, а́)	Number
НЫ́НЧЕ, НЫ́НЕ	Now, at present
Ныря́ть	To dive
НЮ́ХАТЬ	To smell (also to sniff)

О, о.

О, о́бо, об	About
О́ба	Both
Обвиня́ть	To accuse
ОБЕ́Д (а, ы)	Dinner
Обезья́на (ы, ы)	Monkey
ОБЕСПЕ́ЧИТЬ	To secure, guarantee
ОБЕЩА́ТЬ	To promise
Обита́ть	To lodge, reside, live
ОБОЗРЕ́НИЕ (я, я)	The review
О́блако (а, а́)	Cloud
Облегче́ние (я, я)	The relief
Облегчи́ть	To relieve, facilitate
Обме́н (а, ы)	Exchange, barter
ОБНАРУ́ЖИВАТЬ	To discover
Ободря́ть	To cheer up
Обозре́ние	Review
ОБОНЯ́ТЬ	To smell
Обороня́ть	To defend
Оборо́на (ы, ы)	Defence
О́браз (а, ы)	Image, shape
О́браз (а, а́) (ико́на)	Image, ikon
ОБРАЗЕ́Ц (зца́, ы́)	Model, pattern, sample
ОБРАЗОВА́ТЬ	To form, educate
Обра́тно	Back, inversely
ОБСТОЯ́ТЕЛЬСТВО (а, а)	Circumstance
ОБСУЖДА́ТЬ	To discuss
ОБСУЖДЕ́НИЕ (я. я)	Discussion
О́бувь (и, и)	Foot-wear
Обхожде́ние (я, я)	Treatment
Обхва́т (а, ы)	The grip
ОБШИ́РНЫЙ	Vast
ОБЩЕ́СТВЕННОСТЬ (и, и)	Community
ОБЩЕ́СТВЕННЫЙ	Public, social
О́БЩЕСТВО (а, а)	Society
О́БЩИЙ	Common, general
ОБЪЕДИНЯ́ТЬ	To unite
ОБЪЕ́КТ (а. ы)	Object
ОБЪЁМ (а, ы)	Volume, size, bulk
ОБЪЯВЛЯ́ТЬ	To declare
ОБЪЯВЛЕ́НИЕ (я, я)	Declaration

ОБЪЯСНЯ́ТЬ	To explain
ОБЫКНОВЕ́ННЫЙ	Ordinary
ОБЫ́ЧАЙ (я, и)	Use, custom
ОБЫ́ЧНЫЙ	Usual
ОБЯ́ЗАННОСТЬ (и, и)	Duty, obligation
ОБЯЗА́ТЬ	To oblige
Овца́ (ы́, ы)	Sheep
Ого́нь (гня́. й)	Fire
ОГРАНИ́ЧИВАТЬ	To limit
ОДЕВА́ТЬ	To dress
ОДИ́Н	One, a
ОДНА́КО	However
ОДОБРЕ́НИЕ (я, я)	Approval
ОДОБРЯ́ТЬ	To approve
ОДОЛЖА́ТЬ	To lend, oblige
ОДОЛЖЕ́НИЕ(я, я)	Favour
Ожида́ние (я, я)	The waiting
ОЖИДА́ТЬ	To await
ОЗАБО́ЧЕННЫЙ	Anxious
О́зеро (а, озёра)	Lake
ОЗНАЧА́ТЬ	To mean, denote
ОКА́ЗЫВАТЬ	To show
ОКЕА́Н (а, ы)	Ocean
ОКНО́ (а́, а)	Window
О́КОЛО	About
ОКОНЧА́ТЕЛЬНЫЙ	Final
О́КРУГ (а, а́)	District
ОПАСА́ТЬСЯ	To fear
ОПА́СНОСТЬ (и, и)	Danger
Опера́ция (и, и)	Operation
ОПИСА́НИЕ (я, я)	Description
О́ПИСЬ (и, и)	List
ОПИ́СЫВАТЬ	To describe
ОПО́РА (ы, ы)	Support
ОПРА́ВДЫВАТЬ	To justity, acquit
ОПРОВЕРГА́ТЬ	To contradict
ОПРЯ́ТНЫЙ	Clean, neat
О́ПЫТ (а, ы)	Experience, experiment

ОПЯ́ТЬ	Again
ОРГАНИЗА́ЦИЯ (и 'и)	Organization
ОРДИНА́РНЫЙ	Ordinary
Орёл (рла́, ы́)	Eagle
ОРИГИНА́Л (а, ы)	Original
ОРУ́ДИЕ (я, я)	Instrument, tool
Оре́х (а, и)	Nut
ОСВОБОЖДА́ТЬ	To deliver, release
ОСЛОЖНЯ́ТЬ	To complicate
Осма́тривать	To inspect
ОСНО́ВА (ы, ы)	Foundation, basis
ОСНОВНО́Й	Fundamental, essential
ОСНОВА́ТЬ	To found, establish
ОСО́БА (ы, ы)	Person
ОСО́БЕННЫЙ	Particular
ОСО́БЫЙ	Special, separate
ОСТАВА́ТЬСЯ	To remain, stay
ОСТАВЛЯ́ТЬ	To leave
Остана́вливать	To stop, interrupt
О́СТРОВ (а, а́)	Island
О́СТРЫЙ	Sharp
Осужда́ть	To condemn
Осуществля́ть	To realize, carry through
ОСЯЗА́ТЬ	To touch, feel
ОТБО́Р (а, ы)	Selection
Отве́рстие (я, я)	Hole, opening
ОТВЕ́Т (а, ы)	Answer
ОТВЕ́ТСТВЕННОСТЬ (и, и)	Responsibility
ОТВЕЧА́ТЬ	To answer, reply
ОТДА́ЧА (и, и)	Delivery
О́ТДЫХ (а, и)	Rest, repose
ОТДЕ́ЛЬНЫЙ	Separate, individual
ОТЕ́ЛЬ (я, и)	Hotel
ОТЕ́Ц (тца́, ы́)	Father
ОТЗЫВА́ТЬ	To recall
Отка́зывать	To refuse
Открове́нный	Frank
ОТКРЫВА́ТЬ	To open, discover

Откры́тие (я, я)	Discovery
Отличи́тельный	Distinctive
Относи́тельный	Relative
Отноше́ние (я, я)	Relation, connexion
ОТРИЦА́ТЬ	To deny
ОТСУ́ТСТВУЮЩИЙ	Absent
ОТСУ́ТСТВИЕ (я, я)	Absence
ОТСЫЛА́ТЬ	To refer, to send away
ОТСЮ́ДА	Hence
ОТЧЕГО́	Why
ОТЧЁТ (а, ы)	Report, account
ОТ	From, of
ОФИЦЁР (а, ы)	Officer
ОФИЦИА́ЛЬНЫЙ	Official
Охо́титься	To hunt
О́ЧЕНЬ	Very
О́ЧЕРЕДЬ (по о́череди) (и, и)	Turn (in turn)
ОШИ́БКА (и, и)	Error, mistake

П, п.

ПАЙ (я, й)	Share, portion
ПА́ДАТЬ	To fall
ПАКЕ́Т (а, ы)	Package, parcel
ПАКОВА́ТЬ	To pack
Пала́тка (и, и)	Tent
Па́лец (льца, ы)	Finger, toe, thumb
Па́лка (и, и)	Stick
ПА́МЯТЬ (и)	Memory
Па́мятник (а, и)	Monument
Папиро́са (ы, ы)	Cigarette
ПАР (а, ы́)	Steam
ПА́РА (ы, ы)	Pair, couple
Паралле́ль (и, и)	Parallel (n.)
ПАРК (а, и)	Park
ПАРЛА́МЕНТ (а, ы)	Parliament
ПА́РТИЯ (и, и)	Party
Па́рус (а, а́)	Sail
Па́сха (и)	Easter
Пау́к (а́, и́)	Spider
Паха́ть	To plough

Пáхнуть	To smell (intransitive)
Пáчкать	To soil
Пéпел (пла)	Ashes
ПЕРВОНАЧÁЛЬНЫЙ	Original, primary
ПÉРВЫЙ	First
ПЕРЕВÓД (а, ы)	Translation, transfer
ПЕРЕВОДИ́ТЬ	To translate, to transfer
ПÉРЕД	Before
Перемéна (ы, ы)	Change, alteration
ПЕРЕМЕНИ́ТЬ	To alter, change
Переми́рие (я, я)	Armistice, truce
ПЕРЕПИ́СКА (и, и)	Correspondence
Переры́в (а, ы)	Interruption
Переходи́ть	To cross over
ПЕРИ́ОД (а, а)	Period
ПЕРÓ (á, ья)	Feather, pen
Пéрсик (а, и)	Peach
ПЕРСÓНА (ы, ы)	Person
Перчáтка (и, и)	Glove
ПЁС (псá, ы́)	Dog
ПЕСНЬ (и, и)	Song
Песóк (скá, и́)	Sand
Петля́ (и́, и)	Stitch, noose
Петýх (á, и́)	Cock
ПЕТЬ	To sing
ПЕЧÁЛЬ (и, и)	Sadness
Печáть (и, и)	Seal, press
ПЕЧÁТАТЬ	To print
Печь (и́, и)	Oven, stove
Печь	To bake
Пиани́ст (а, ы)	Pianist
ПИ́ВО (а)	Beer
Пилá (ы́, ы)	Saw (n.)
Пирóг (á, и́)	Pie
Пирожóк (жкá, жки́)	Cake
ПИСÁТЬ	To write
ПИСÁНЬЕ (я, я)	The writing
ПИСÁТЕЛЬ (я, и)	Author, writer
ПИСÉЦ (сцá, ы́)	Clerk
ПИСЬМÓ (á, а)	Letter
ПИСЬМОВОДИ́ТЕЛЬ (я, и)	Secretary
ПИТЬ	To drink
ПИТЬЁ (я́, я)	The drink, beverage
ПИ́ЩА (и)	Food
Пищеварéние (я, я)	Digestion
Плáвание (я, я)	Swimming
ПЛÁВАТЬ	To swim, to float
Плáкать	To weep, to cry
Плáмя (ени)	Flame
ПЛАН (а, ы)	Plan, scheme
Планéта (ы, ы)	Planet
ПЛÁТА (ы, ы)	Fee, charge
ПЛАТЁЖ (ежá, и́)	Payment
ПЛАТИ́ТЬ	To pay
ПЛАТÓК (ткá, и́)	Handkerchief
Платфóрма (ы, ы)	Platform
ПЛÁТЬЕ (я, я)	Clothes, garment
Плевáть	To spit
ПЛÉМЯ (ени, á)	Stock, race, tribe
Плечó (á, и)	Shoulder
ПЛОД (á, ы́)	Fruit
Плодорóдный	Fertile
Плóский	Flat
ПЛОХÓЙ	Bad
ПЛÓЩАДЬ (и, и)	Square (n.)
Плуг (а, и)	Plough (n.)
ПЛЫТЬ	To swim
Пляж (а, и)	Beach
Плясáть	To dance
ПО	On, over, at, in
ПОБÉДА (ы, ы)	Victory
Побеждáть	To conquer
Побуждáть	To urge, induce
Побуждéние	The impulse
ПÓВАР (а, á)	Cook (masc.)
Поведéние (я)	Behaviour
Повелевáть	To command
Повéренный (ого, ые)	Agent, attorney
ПОВÉРХ	Above, over
Повéрхность (и, и)	Surface, the plane
Повиновáться	To obey
ПОВТОРЯ́ТЬ	To repeat
ПÓВЕСТЬ (и, и)	Novel
ПОГÓДА (ы, ы)	Weather
ПОД	Under
Подáрок (рка, и)	Present, gift
ПÓДАТЬ (и, и)	Rate, tax
Подборóдок (дка, и)	Chin
Подвлáстный	Dependent, subordinate
ПÓДДАННЫЙ (ого, ые)	Subject (adj. and n.)
ПОДДÉРЖИВАТЬ	To support
ПОДЛЕЖÁТЬ	To be subject to
Пóдлинник (а, и)	Original
Поднимáть	To lift up, raise
ПОДНÓС (а, ы)	The tray
ПОДПИ́СЫВАТЬ	To sign
Подрóбность (и, и)	Detail
Подýшка (и, и)	Cushion, pillow
Подчиня́ть	To submit, subjugate
ПОЖÁЛУЙ	Perhaps
ПОЖÁЛУЙСТА	Please
ПОЖÁР (а, ы)	Fire
Позади́	Behind
ПОЗВОЛÉНИЕ (я, я)	Permission
ПОЗВÓЛИТЬ	To permit, to let
ПÓЗДНО	Late
Поздравля́ть	To congratulate
ПОЗИ́ЦИЯ (и, и)	Position
ПОКÁ	Until, while
Покáзывать	To show, exhibit
ПОКÁМЕСТ	Meanwhile, until
Покóйный	Calm, comfortable, deceased, late (of a dead person)
Покидáть	To quit, leave
Покори́ть	To conquer, subjugate
Покрóв (а, ы)	Cover
Покрови́тельство (а)	Protection
Покрывáть	To cover

Покупатель (я, и)	Purchaser, customer
ПОКУПА́ТЬ	To purchase
ПОКУ́ПКА (и, и)	Purchase
ПОКУША́ТЬСЯ	To attempt
ПО́ЛДЕНЬ (дня)	Midday, noon
ПОЛ (а, ы́)	Floor
ПОЛ (а)	Sex
ПО́ЛЕ (я, я́)	Field
ПОЛЕЗНЫЙ	Useful
ПОЛЁТ (а, ы)	The flight, soaring
ПОЛИРОВА́ТЬ	To polish
По́лис (а, ы or а́)	Policy (of insurance)
ПОЛИ́ТИКА (и)	Politics, policy
ПОЛИ́ЦИЯ (и, и)	Police
Полк (а́, и́)	Regiment
ПО́ЛКА (и, и)	Shelf
ПО́ЛНОСТЬЮ	Fully
ПО́ЛНЫЙ	Full, complete
ПОЛОВИ́НА (ы, ы)	Half
ПОЛОЖЕ́НИЕ (я, я)	Situation, condition
ПО́ЛНОЧЬ (и)	Midnight
ПОЛОТНО́ (а́, а)	Linen (material)
Полуо́стров (а, а́)	Peninsula
Полуша́рие (я, я)	Hemisphere
ПОЛУЧА́ТЬ	To receive, obtain, get
ПО́ЛЬЗА (ы)	Advantage, profit
По́люс (а, ы)	Pole
ПО́ЛЫЙ	Hollow
ПО́МНИТЬ	Remember
ПОМОГА́ТЬ	Help, assist (v.)
ПО́МОЩЬ (и)	Help, assistance, aid
ПОНИМА́ТЬ	To understand
ПОНЫ́НЕ	Up till now
ПОМЕЩА́ТЬ	To place
Понижа́ть	To lower, reduce
ПОНЯ́ТИЕ (я, я)	Notion, idea
ПОПЕРЁК	Across
Пополам	By halves, in two
ПОПОЛНЯ́ТЬ	To complete
Пополу́дни	In the afternoon
Пополу́ночи	After midnight
Поправля́ть	To correct
ПО́ПРОСТУ	Simply
ПОПЫ́ТКА (и, и)	Attempt
ПОРА́	Time, it is time
ПОРО́Ю	Sometime
Порица́ть	To blame
ПО́РОВНУ	Equally
ПО́РОЗНЬ	Separately
По́рох (а)	The gunpowder
По́ртить	To spoil
Портно́й (о́го, ы́е)	The tailor
Портре́т (а, ы)	The portrait
ПОРТ (а́, ы́)	Port, harbour
Поруча́ть	To charge, to commission
Поруче́ние (я, я)	Commission, mandate
ПО́РЧА (и, и)	Damage
ПОРЯ́ДОК (дка, и)	Order, turn
Посвяща́ть	To devote, dedicate
ПОСЛА́НИЕ (я, я)	Message
ПО́СЛЕ	After, afterwards
ПОСЛЕ́ДНИЙ	Last, latest, latter
ПО́СЛЕЗА́ВТРА	Day after tomorrow
ПОСРЕДИ́	Among
ПОСТЕ́ЛЬ (и, и)	Bed, bedding
ПОСТЕПЕ́ННЫЙ	Gradual
ПОСТО́ЛЬКО	As much . . . as
ПОСТОРО́ННИЙ	Strange, stranger, outsider
Постоя́нный	Constant, permanent
Пост (а́, ы́)	Post, position, function
ПОСЫЛА́ТЬ	To send
ПОСЕЩА́ТЬ	To visit
ПОТЕ́РЯ (и, и)	Loss
Потоло́к (лка́, и́)	Ceiling
ПОТОМУ́ ЧТО	Because
ПОТО́М	Thereupon. afterwards
ПОТРЕБЛЯ́ТЬ	To consume, spend
Пот (а, ы)	Sweat
ПОУТРУ́	In the morning
Походи́ть	To resemble
По́хороны (plural)	Funeral
Поцелу́й (я, и)	A kiss
ПО́ЧВА (ы, ы)	Soil, ground
ПОЧЕМУ́	Why
ПОЧЁМ	How much
По́честь (и, и)	Honour
Почёт (а, ы)	Respect
ПО́ЧТА (ы)	Post, mail
ПОЧТИ́	Almost
ПО́ШЛИНА (ы, ы)	Tax, duty
ПО́ЕЗД (а, а́)	Train
ПОЭ́ЗИЯ (и)	Poetry
ПОЭ́МА (ы, ы)	Poem
ПОЭ́Т (а, ы)	Poet
ПОЭ́ТОМУ	Therefore
ПО́ЯС (а, а́)	Belt
ПРА́ВДА (ы, ы)	Truth
ПРА́ВИЛО (а, а)	Rule, principle
ПРАВИ́ТЕЛЬСТВО	Government
ПРА́ВИТЬ	To govern
ПРА́ВО (а, а́)	Right, law
ПРАВОСУ́ДИЕ (я)	Justice
ПРА́ВЫЙ	Right
Пра́здник (а, и)	Holiday
Пра́здновать	To celebrate
ПРА́КТИКА (и, и)	Practice
Практи́ческий	Practical
Превосхо́дный	Excellent
ПРЕД	Before, in front of
Предводи́тель (я, и)	Leader
Предлага́ть	To propose, offer
ПРЕДМЕ́Т (а, ы)	Subject, matter
Предохраня́ть	To preserve, protect

Предполага́ть	To suppose, assume
Предпочита́ть	To prefer
Председа́тель (я, и)	President, chairman
Представля́ть	To introduce
ПРЕДЫДУ́ЩИЙ	Previous
Предъявля́ть	To present, produce
Представитель (я, и)	The representative
Предупрежда́ть	To prevent, to warn
ПРЕДЕ́Л (а, ы)	Limit, term
ПРЕ́ЖНИЙ	Former
Президе́нт (а, ы)	President
Презре́ние	Contempt
Прекра́сный	Beautiful
ПРЕЛЕ́СТНЫЙ	Delightful, charming
Пре́лесть (и, и)	Charm
Пренебрега́ть	To neglect
Преоблада́ть	To prevail over
ПРЕСТУПЛЕ́НИЕ (я, я)	Crime
Прерыва́ть	To interrupt
ПРИ	By, near
Пре́сса (ы)	The press
Прибли́зиться	To approach
ПРИБО́Р (а, ы)	Apparatus
ПРИБЫВА́ТЬ	To arrive
ПРИ́БЫЛЬ (и, и)	Gain, advantage, profit
Прибы́тие (я)	Arrival
Привиле́гия (и, и)	Privilege
Привлека́ть	To attract
Привлека́тельный	Attractive
Привы́чка (и, и)	Habit
ПРИВЕ́ТСТВОВАТЬ	To welcome, greet
Привя́зывать	To attach, tie
ПРИГЛАША́ТЬ	To invite
ПРИГОВО́Р (а, ы)	The sentence, judgement
Приглаше́ние (я, я)	Invitation
Приготовля́ть	To prepare
Приготовле́ние (я, я)	Preparation
ПРИЗНАВА́ТЬ	To acknowledge, recognize
Призва́ние (я, я)	Vocation
Приз (а, ы)	Prize
Приложе́ние (я, я)	Application, addition
Прика́зывать	To order, command
Приле́жный	Diligent
Применя́ть	To apply, put into practice
ПРИМЕ́Р (а, ы)	Example
ПРИМЕЧА́НИЕ (я, я)	Remark, note
ПРИНАДЛЕЖА́ТЬ	To belong to, relate to
ПРИНИМА́ТЬ	To receive, accept
ПРИНОСИ́ТЬ	To bring
Принужда́ть	To force, compel
При́нцип (а, ы)	Principle
ПРИРО́ДА (ы)	Nature
Приро́дный	Natural
Присты́женный	Ashamed
Прису́тствие (я)	Presence
ПРИСУ́ТСТВОВАТЬ	To attend, be present
ПРИЧИ́НА (ы, ы)	Cause
Притяже́ние ((я, я)	Attraction
Причиня́ть	To cause
ПРИЕЗЖА́ТЬ	To arrive (not on foot)
ПРИХОДИ́ТЬ	To arrive (on foot)
Прия́тный	Agreeable, pleasant
Про́бка (и, и)	The cork
ПРОБЛЕ́МА (ы, ы)	The problem
Про́бочник (а, и)	The corkscrew
Про́бовать	To try, test
ПРОГРЕ́СС (а, ы)	The progress
ПРОДАВА́ТЬ	To sell
Про́волока (и, и)	The wire
Прода́жа (и, и)	Sale
ПРОДОЛЖА́ТЬ	To continue
ПРОДУ́КТ (а, ы)	Product
ПРОЕ́КТ (а, ы)	Plan, project
ПРО́ЗА (ы)	Prose
ПРОИЗВОДИ́ТЬ	To produce
ПРОИЗВО́ДСТВО (а, а)	Production
ПРОИСХОДИ́ТЬ	To occur, happen
ПРОИСШЕ́СТВИЕ (я, я)	Event
ПРОМЫ́ШЛЕННОСТЬ (и, и)	Industry
ПРОПО́РЦИЯ (и, и)	Proportion
ПРОСИ́ТЬ	To ask, beg
Просма́тривать	To examine
Просмо́тр (а, ы)	Examination, survey
ПРОСПЕ́КТ (а, ы)	The prospect
ПРОСТО́Й	Simple, mere
ПРОСТРА́НСТВО (а, а)	Space
Простыня́ (й, и)	Sheet
Про́сьба (ы, ы)	Request, application
Проте́кция (и, и)	Protection
Проте́ст (а, ы)	Protest
Противоре́чить	To contradict
ПРО́ТИВ	Against
ПРОФЕ́ССИЯ (и, и)	Profession
Профе́ссор (а, а́)	Professor
ПРОХЛА́ДНЫЙ	Cool
Проходи́ть	To proceed, pass by
Проце́сс (а, ы)	Process, suit
ПРО́ЧИЙ	Other, remaining
ПРОЧЬ	Away, be off
ПРО́ЧНЫЙ	Steady, solid
ПРО́ШЛЫЙ	Past, former
ПРОЩА́ТЬ	To forgive
ПРОЩЕ́НИЕ (я, я)	Pardon, forgiveness
Пры́гать	To jump
ПРЯ́МО	Straight, direct
Пти́ца (ы, ы) -	Bird
ПУ́БЛИКА (и)	Public
Публикова́ть	To publish
ПУНКТ (а, ы)	Point
Пусто́й	Empty, vain
Пуга́ть	To scare, frighten
Пусты́ня (и, и)	Desert
ПУ́ДРА (ы, ы)	The powder
ПУТЬ (и́, и́)	Way, course
ПУТЕШЕ́СТВИЕ (я, я)	Journey
ПУТЕШЕ́СТВОВАТЬ	To journey, travel
Пу́хнуть	To swell
Пу́шка (и, и)	Gun
Пчела́ (ы́, ы)	Bee
Пшени́ца (ы)	Wheat
ПЫЛЬ (и)	Dust

Пы́лкий	Eager, fiery
Пы́льный	Dusty
Пятно́ (á, а)	The spot

Р, р.

РАБО́ТАТЬ	To work
РАБО́ТА (ы, ы)	Work
РАБО́ЧИЙ (его, ие)	Worker, artisan
РА́ВНЫЙ	Equal
РАД	Glad
РА́ДОСТЬ (и, и)	Joy
Ра́достный	Cheerful, joyful
Разбива́ть	To smash
Развёртывать	To display, to untold
РАЗВИВА́ТЬ	To develop
Развя́зывать	To loosen, to undo
РАЗГОВО́Р (а, ы)	Conversation
РАЗДЕ́Л (а, ы)	Division
РАЗДЕЛЯ́ТЬ	To divide
РА́ЗНЫЙ	Different
РАЗМЕ́Р (а, ы)	Size
РА́ЗНИЦА (ы, ы)	Difference
Разнообра́зие (я, я)	Variety, diversity
РАЗНООБРА̀ЗНЫЙ	Various, diverse
Разочаро́вывать	To disappoint
Разруша́ть	To destroy
Разруше́ние (я, я)	Destruction
РАЗУЗНАВА́ТЬ	To inquire
РАЗУ́МНЫЙ	Reasonable
РА́ЗУМ (а)	Reason, mind
Ра́ковина (ы, ы)	The shell
Ра́ма (ы, ы)	Frame
Ра́на (ы, ы)	Wound
Ранг (а, и)	Rank, class
РА́ННИЙ	Early (adj.)
РА́НО	Early (adv.)
Ра́са (ы, ы)	Race (of men, etc.
РАСПИ́СКА (и, и)	The receipt
Распла́та (ы, ы)	Settlement
Распла́чиваться	To settle
Располага́ть	To dispose
Располо́женный	Disposed
Распределя́ть	To distribute
Распределе́ние (я, я)	Distribution
РАССКА́З (а, ы)	Story, tale
Расстоя́ние (я, я)	Distance
РАССЧЁТ (а, ы)	Account
РАСТЕ́НИЕ (я, я)	Plant
РАСТИ́	To grow
Растя́гивать	To stretch
РАСХО́Д (а, ы	Expenditure, expense
Расширя́ть	To extend
Реа́кция (и, и)	Reaction
РЕА́ЛЬНЫЙ	Real
РЕБЁНОК (нка, я́та)	Child, infant
Ревни́вый	Jealous
Революция (и, и)	Revolution
РЕ́ДЕНЬКИЙ	Thin, sparse
РЕ́ДКИЙ	Scarce, rare
РЕГУЛЯ́РНЫЙ	Regular
РЕЕ́СТР (а, ы)	The register, record
РЕ́ЗАТЬ	To cut
РЕЗИ́НА (ы, ы)	Rubber
РЕЗУЛЬТА́Т (а, ы)	Result
РЕКА́ (и́, и)	River
РЕКОМЕНДОВА́ТЬ	To recommend
РЕ́ДКО	Seldom
Рели́гия (и, и)	Religion
Религио́зный	Religious
РЕЛЬС (а, ы)	Rail
РЕМЕСЛО́ (á, мёсла)	Trade
РЕСПУ́БЛИКА (и, и)	Republic
РЕЧЬ (и, и)	Speech
РЕША́ТЬ	To decide
РЕШЕ́НИЕ (я, я)	Decision
Рис (а)	Rice
РИСОВА́ТЬ	To draw, design
РИСУ́НОК (нка, и)	Drawing, design
Ритм (а, ы)	Rhythm
Рог (а, á)	Horn
Роди́ть	To bear, beget
РОДИ́ТЕЛИ	Parents
РО́ДСТВЕННИК (а, и)	Relative (n.), relation
РОЖДЕ́НИЕ (я, я)	Birth
День рожде́ния	Birthday
Рождество́ (á)	Christmas
Ро́за (ы, ы)	Rose
РОСТ (а)	Growth
РОТ (ртá, ы́)	Mouth
Руба́ха (и, и)	Shirt
Рудни́к (á, и́)	Mine (coal, iron, etc.
Ружьё (я́, я)	Gun, musket, rifl
РУКА́ (и́, и)	Hand, arm
РУКОВОДИ́ТЬ	To guide
Ру́копись (и, и)	Manuscript
Руль (я́, и́)	Rudder
Руча́ться	To warrant, guarante
Руче́й (ья́, и́)	Brook, stream
Ру́чка (и, и)	The handle
РЫ́БА (ы, ы)	Fish
РЫ́НОК (нка, и)	Market
Рыть	To dig, hollow ou
Ряд (а, ы́)	Row, range

С, с.

С (со)	With
САДИ́ТЬ	To set, put, plan
САД (а, ы́)	Garden
Са́льдо (not declined)	Balance
САМ	Self
САМО́	Itself
СА́МЫЙ	Same
Са́ни (plural)	Sledge, sleigh
САПО́Г (á, и́)	Boot
СА́ХАР (а)	Sugar
СБОР (а, ы)	Collection
Сва́дьба (ы, ы)	Wedding
Сва́я (и, и)	The pile
СВЕ́ДЕНИЕ (я, я)	Experience, informatio
СВЕ́ЖИЙ	Fresh
Свет (а)	The light
Све́тлый	Light (adj.)

Светло	Light (adv.)
Свёрток (тка, и)	Roll, packet, parcel
Свида́ние (я, я)	Meeting
ДОСВИДА́НЬЯ	Good-bye, au revoir
Свиде́тель (я, и)	Witness
Свиде́тельство (а, а)	Certificate
Свине́ц (нца́)	Lead (n.)
Свинья́ (и́, и)	Pig, sow
Свиста́ть	To whistle
СВОБО́ДА (ы, ы)	Freedom, liberty
Свобо́дный	Free
Свя́зывать	To tie, to bind
Свяще́нник (а, и)	Priest
СГОВА́РИВАТЬСЯ	To agree
Сдава́ть внаймы́	To let, to lease
СЕ́ВЕР (а)	The north
СЕГО́ДНЯ	Today
СЕЗО́Н (а, ы)	Season
Сейча́с	At once
Секрета́рь (я́, и́)	Secretary
СЕКРЕ́Т (а, ы)	Secret (n).
СЕКУ́НДА (ы, ы)	Second (measure of time)
Се́кция (и, и)	The section
СЕЛО́ (а́, сёла)	Village
СЕМЬЯ́ (и́, и)	Family
Се́мя (ени, а́)	Seed
Се́но (а)	Hay
Сень (и, и)	Shade, protection
СЕРДИ́ТЫЙ	Angry
СЕ́РДЦЕ (а, а́)	Heart
СЕРЕБРО́ (а́)	Silver
СЕРЕДИ́НА (ы, ы)	Middle
СЕ́РЫЙ	Grey
Серьёзный	Serious
СЕСТРА́ (ы́, сёстры)	Sister
Сеть (и, и)	Net
Се́ять	To sow
СЗА́ДИ	Behind
СИДЕ́НИЕ (я, я)	Seat, sitting
СИДЕ́ТЬ	To sit
СИ́ЛА (ы, ы)	Strength
СИ́ЛЬНЫЙ	Strong
Симпа́тия (и, и)	Sympathy
СИ́НИЙ	Blue
СИСТЕ́МА (ы, ы)	System
Сия́ть	To shine
СКАЗА́ТЬ	To say, tell
Скака́ть	To jump, skip, gallop
Скала́ (ы́, ы)	Rock
СКВОЗЬ	Through
Скла́дка (и, и)	The fold, crease
СКЛОНЯ́ТЬ	To incline, bend
Скользи́ть	To slide, slip
СКО́ЛЬКО	How much, how many
Склон (а, ы)	The slope
СКОРБЬ (и, и)	Sorrow
СКО́РО	Quickly, soon
СКО́РЫЙ	Quick
СКОРЕ́Е	Rather (adv.)
СКОТ (а́, ы́)	Cattle
Скрыва́ть	To conceal
Скры́тый	Latent, hidden
СЛА́БЫЙ	Weak, slight
СЛА́ВА (ы)	Glory, fame
СЛА́ВНЫЙ	Famous, excellent, charming
СЛА́ДКИЙ	Sweet
СЛЕ́ДОВАТЬ	To follow
СЛЕД (а́, ы́)	Trace
СЛЕЗА́ (ы́, слёзы)	Tear (n.)
Слепо́й	Blind
СЛИ́ВКИ (plural)	Cream
СЛИ́ШКОМ	Too much
СЛОВА́РЬ (я́, и́)	Dictionary
СЛО́ВО (а, а́)	Word
Слуга́ (и́, и)	Servant
СЛУ́ЖБА (ы, ы)	Service, job, work
СЛУЖИ́ТЬ	To serve, work
СЛУХ (а, и)	Hearing, ear, rumour
СЛУ́ЧАЙ (я, и)	Accident, occasion, case, chance
СЛУЧИ́ТЬСЯ	To happen
СЛУ́ШАТЬ	To listen
СЛЫ́ШАТЬ	To hear
СМЕ́ЛЫЙ	Bold, daring
СМЕРТЬ (и, и)	Death
Сме́ртный	Mortal
СМЕТЬ	To dare, venture
СМЕХ (а)	Laugh, laughter
Сме́шивать	To mix, confuse
СМЕШНО́Й	Funny, laughable
СМЕЯ́ТЬСЯ	To laugh
Сми́рный	Quiet, peaceable
Смире́нный	Humble
СМОТРЕ́ТЬ	To look, regard
Смышлённый	Clever, intelligent
СНАБЖА́ТЬ	To furnish, supply
СНАРУ́ЖИ	Outside
СНИ́ЗУ	From below
Сни́ться	To dream
СНО́ВА	Anew, again
Сновиде́ние (я, я)	Dream (n.)
Снег (а, а́)	Snow
СОБА́КА (и, и)	Dog
СОБИРА́ТЬ	To gather
СО́БСТВЕННЫЙ	Own
СОБРА́НИЕ (я, я)	Assembly
Соверша́ть	To perform, accomplish
СОВЕРШЕ́ННЫЙ	Perfect, thorough
Со́весть (и)	Conscience
СОВЕ́Т (а, ы)	Counsel, advice, council
СОВЕ́ТОВАТЬ	To advise
СОВЕЩА́НИЕ (я, я)	Conference
СОВРЕМЕ́ННЫЙ	Modern
СОВСЕ́М	Altogether, entirely
СОГЛА́СНО	According
СОГЛАША́ТЬСЯ	To consent
СОГЛАШЕ́НИЕ (я, я)	Agreement
СОДЕРЖА́ТЬ	To hold, maintain
Соде́йствовать	To co-operate
Содрага́ние (я, я.	The thrill

СОЕДИНЯ́ТЬ	To unite
СОЖАЛЕ́ТЬ	To regret, pity
К СОЖАЛЕ́НИЮ	Unfortunately
СОЗДАВА́ТЬ	To create
Созда́ние (я, я)	Creature, creation
Созна́тельный	Conscious
СОЛДА́Т (а, ы)	Soldier
Соли́дный	Solid
СО́ЛНЦЕ (а, а)	Sun
Со́лнечный свет	Sunshine
Соло́ма (ы, ы)	Straw
СОЛЬ (и, и)	Salt
СОМНЕВА́ТЬСЯ	To doubt
СОМНЕ́НИЕ (я, я)	Doubt
СОН (сна́, ы́)	Sleep, dream
СО́ННЫЙ	Sleepy
СООБЩА́	Jointly, in common
СООБЩА́ТЬ	To communicate
СООРУЖЕ́НИЕ (я, я)	Building, construction
Сопе́рничать	To compete
Сопровожда́ть	To accompany
Соревнова́ние (я, я)	Competition, rivalry
СОРТ (а, а́)	Sort, kind
Сосна́ (ы́, ы)	The pine
Сосредото́чить	To concentrate
СОСТОЯ́ТЬ	To be, consist
Состоя́ние (я, я)	Condition, state, wealth
СОСЕ́Д (а, и)	Neighbour
СОСЕ́ДСТВО (а, а)	Neighbourhood
Сосу́д (а, ы)	The vessel
Со́хнуть	To dry
Сохраня́ть	To keep, preserve
СОХРА́ННЫЙ	Safe (adj.).
Сочиня́ть	To compose, invent
Сочини́тель (я, и)	Author, composer
Сочу́вствовать	To sympathize
Сочу́вствие (я, я	Sympathy
СОЮ́З (а, ы)	Union
Спаса́ть	To save, rescue
Спасе́ние (я)	Safety, salvation
СПАСИ́БО	Thanks, thank you

СПАТЬ	To sleep
Спе́лый	Ripe
СПЕХ (а)	Haste
СПЕЦИА́ЛЬНЫЙ	Special
СПЕШИ́ТЬ	To hasten
СПИНА́ (ы́, ы)	The back (of a man, animal)
Спирт (а, ы)	Spirit (alcohol)
СПИ́СОК (ска, и)	Copy, list
СПИ́ЧКА (и, и)	Match (for lighting)
СПОКО́ЙНЫЙ	Quiet, calm
СПОЛНА́	Entirely
Спо́рить	To argue, dispute
Спо́соб (а, ы)	Means, method
СПОСО́БНЫЙ	Capable, able
Спосо́бность (и, и)	Capacity
Справедли́вость (и, и)	Justice, equity
Справедли́вый	Just, equitable
СПРА́ВКА (и, и)	Information, inquiry
Спорт (а, ы)	The sport
Спотыка́ться	To trip, stumble
Сра́внивать	To compare
СПЯ́ЩИЙ	Asleep, sleeping
СРАВНЕ́НИЕ (я, я)	Comparison
СРА́ЗУ	All at once, there and then
СРЕДА́ (ы́, ы)	The middle (also Wednesday)
СРЕ́ДНИЙ	Middle, average
СРОК (а, и)	Term, date
СРО́ЧНЫЙ	Urgent
Ссо́ра (ы, ы)	Quarrel
Ссыла́ться	To refer to
Ссы́лка (и, и)	Reference, deportation
СТА́ВИТЬ	To place, put
Ста́до (а, а́)	Herd, flock
СТАКА́Н (а, ы)	Glass, tumbler
СТАЛЬ (и)	Steel
СТА́НЦИЯ (и, и)	Station
СТАРА́НИЕ (я, я)	Effort
Стари́нный	Ancient
СТА́РЫЙ	Old

СТАТЬ	To become, begin
Статья́ (и́, и́)	Article, clause
Сте́бель (бля, и)	Stem
Стекло́ (а́, стёкла)	Glass (material)
СТЕНА̀ (ы́, ы)	Wall
СТЕ́ПЕНЬ (и, и)	Degree
Стере́чь	To protect, guard
Стиль (я, и)	Style
Стира́ть	To wash (linen), to rub off
Стих (а́, и́)	Verse
Стлать	To spread
СТО́ИТЬ	To cost
СТОЛ (а́, ы́)	Table
СТО́ЛЬКО	So many
Столе́тие (я, я)	Century
Сторожи́ть	To watch, guard
СТОРОНА́ (ы́, ы)	Side, party
СТОЯ́ТЬ	To stand
СТРАДА́ТЬ	To suffer
СТРАНА́ (ы́, ы)	Country, land
СТРАНИ́ЦА (ы, ы)	Page
СТРА́ННЫЙ	Strange, queer
Страсть (и, и)	Passion
СТРАХ (а, и)	Fear
Страхова́ть	To insure
Страши́ть	To terrify
Страхова́ние (я, я)	The insurance
Стра́шный	Frightful, awful
Стричь	To cut (hair), to shear (wool)
Стро́гий	Severe
Стро́ить	To build, construct
СТРОЙ (я, и)	Front, order of society
Строе́ние (я, я)	Structure, building
Струна́ (ы́, ы)	String (musical instrument)
Стреля́ть	To shoot
СТУДЕ́НТ (а, ы)	Student
СТУЛ (а, ья)	Chair
Ступе́нька (и, и)	Step
Стуча́ть	To knock
СТЫД (а́)	Shame
СУД (а́, ы́)	Court of justice

Су́дарь (я, и)	Sir
Суда́рыня (и, и)	Madam
СУ́ДНО (а, суда́)	Ship, vessel
СУДЬБА́ (ы́, ы)	Destiny, fate
СУДИ́ТЬ	To judge
СУДЬЯ́ (и́, и)	Judge
СУЖДЕ́НИЕ (я, я)	Judgement
СУКНО́ (а́, а)	Cloth
СУ́МКА (и, и)	Bag
СУ́ММА (ы, ы)	Sum, amount
СУНДУ́К (а́, и́)	Box, trunk
СУП (а, ы́)	Soup
СУХО́Й	Dry
Суши́ть	To dry
Существова́ние (я, я)	Existence
Существо́ (а́, а́)	Creature, substance
СУЩЕСТВОВА́ТЬ	To exist
СХО́ЖИЙ	Similar
Сце́на (ы, ы)	Scene, stage
СЧА́СТЬЕ (я)	Luck, happiness, fortune
Счастли́вый	Happy, fortunate
СЧЁТ (а, ы or а́)	Account, bill
СЧИТА́ТЬ	To count, calculate
СЫН (а, овья́)	Son
Сыро́й	Damp, raw
СЫР (а, ы́)	Cheese
СЮДА́	Here, hither
СЮЖЕ́Т (а, ы)	Subject, matter
СЮРПРИ́З (а, ы)	Surprise

Т, т.

Таба́к (а́, и́)	Tobacco
ТА́ЙНЫЙ	Secret (adj.)
ТАКО́Й	Such
Та́кса (ы, ы)	Tax, tariff
ТАК	Thus
ТА́КЖЕ	Too, also
Тамо́жня (и, и)	Custom house
ТАМ	There
Танцова́ть	To dance
ТАРЕ́ЛКА (и, и)	Plate
ТВЁРДЫЙ	Hard, firm
Твори́ть	To create
ТЕА́ТР (а, ы)	Theatre
Теле́га (и, и)	The cart
ТЕЛЕГРА́ММА (ы, ы)	Telegram
ТЕЛЕГРА́Ф (а)	Telegraph office
Телеграфи́ровать	To telegraph
ТЕЛЕФО́Н (а, ы)	Telephone
ТЕ́ЛО (а, а́)	Body, flesh
ТЁМНЫЙ	Dark, obscure
Тенде́нция (и, и)	Tendency
Тень (и, и)	Shade, shadow
Тео́рия (и, и)	Theory
ТЕПЕ́РЬ	Now, at present
ТЁПЛЫЙ	Warm
Тере́ть	To rub
Те́рмин (а, ы)	Term (expression)
Терпели́вый	Patient
Терпе́ние (я)	Patience
ТЕРПЕ́ТЬ	To suffer, endure
ТЕРРИТО́РИЯ (и, и)	Territory
ТЕРЯ́ТЬ	To lose
Те́сто (а)	Paste, dough
Те́сть (я, и)	Father-in-law
Тётка (и, и)	Aunt
ТЕЧЬ	To flow
ТЕЧЕ́НИЕ (я, я)	Current, course
Тёща (и, и)	Mother-in-law
Тигр (а, ы)	Tiger
ТИП (а, ы)	Type
Ти́тул (а, ы)	Title
ТИ́ХИЙ	Gentle, calm
ТИШЬ (и)	Calm, quietness
ТОВА́Р (а, ы)	Merchandise, goods
ТОВА́РИЩ (а, и)	Comrade, partner
ТОГДА́	Then
ТО́-ЕСТЬ	That is to say
ТОЛПА́ (ы́, ы)	Crowd
ТО́ЛСТЫЙ	Thick, stout
Толчо́к (чка́, и́)	Shock, jerk
ТО́ЛЬКО	Only
Тон (а, ы)	Tone
Том (а, ы or а́)	Volume
ТО́НКИЙ	Thin, fine
То́нна (ы, ы)	Ton
Тону́ть	To sink
Топо́р (а́, ы́)	Axe
Торгова́ть	To deal, to trade
То́рмаз (а, а́)	Brake
ТОРОПИ́ТЬ	To hurry
ТОРОПИ́ТЬСЯ	To hasten
ТО́ТЧА́С	Directly, at once
ТОТ, ТА, ТО	That
ТО́ЧКА (и, и)	Point
ТО́ЧНЫЙ	Exact, punctual
ТРАВА́ (ы́, ы)	Grass
Тради́ция (и, и)	Tradition
Тра́нспорт (а)	Transport
Трансфе́рт (а, ы)	Transfer
Тра́тить	To waste
Тра́тта (ы, ы)	Bill, draft
ТРЕ́БОВАТЬ	To claim, demand
Трево́жить	To alarm, excite
Трети́ровать	To treat (badly)
Тре́щина (ы, ы)	The crack
ТРО́ГАТЬ	To touch
Тропа́ (ы́, ы)	Path
Труба́ (ы́, ы)	Pipe, tube
Тру́бка (и, и)	Tobacco pipe, tube
ТРУД (а́, ы́)	Work, labour
ТРУ́ДНЫЙ	Difficult
Тря́пка (и, и)	Rag
Трясти́	To shake
Туго́й	Stiff, tight
ТУДА́	Thither, there
ТУЗЕ́МЕЦ (мца, ы)	Native
Тума́н (а, ы)	Fog, mist
Туне́ль (я, и)	Tunnel
ТУТ	Here
ТЩА́ТЕЛЬНЫЙ	Careful, diligent

Тщесла́вие (я)	Vanity, Ambition
Тюрьма́ (ы́, ы)	Prison, jail
ТЯЖЁЛЫЙ	Heavy
ТЯНУ́ТЬ	To draw, pull

У, у.

У	At
Убива́ть	To kill
Уби́йство (а, а)	Homicide, murder
УБЫ́ТОК (тка, и)	Loss
УБЕЖДА́ТЬ	To convince, persuade
Убе́жище (а, а)	Harbour, refuge
УВЕЛИ́ЧИВАТЬ	To enlarge, increase
УВЕДОМЛЯ́ТЬ	To inform
УВЕРЯ́ТЬ	To assure
Уга́дывать	To guess
Угол (гла́, ы́)	Corner, angle
У́ГОЛЬ ((гля, и)	Coal
Угоща́ть	To entertain, treat
УГРО́ЗА (ы; ы)	Threat
УДАВА́ТЬСЯ	To succeed
Удаля́ть	To remove
Удаля́ться	To retire
УДА́Р (а, ы)	Blow, stroke
УДАРЯ́ТЬ	To strike, beat, hit
УДА́ЧА (и, и)	Luck, success
УДА́ЧЛИВЫЙ	Successtul, lucky
УДИВЛЯ́ТЬ	To astonish
УДО́БНЫЙ	Convenient, comfortable
УДО́БСТВО (а, а)	Comfort, convenience
Удовлетворя́ть	To satisfy
Удовлетворе́ние (я)	Satisfaction
УДОВО́ЛЬСТВИЕ (я, я)	Pleasure
Удостоверя́ть	To certify
Удостовере́ние (я, я)	Certificate
У́жас (а, ы)	Horror, terror
Ужа́сный	Frightful, awful
УЖЕ́	Already
У́жин (а, ы)	Supper
У́зел (эла́, ы́)	The knot
У́ЗКИЙ	Narrow, close
Узнава́ть	To recognize, learn
УКА́ЗЫВАТЬ	To show, indicate
Укрепля́ть	To fix, strengthen
Украше́ние (я, я)	Adornment
Ула́живать	To adjust, settle
У́ЛИЦА (ы, ы)	Street
Ула́живание (я, я)	Adjustment, settlement
Улучша́ть	To improve
Улыба́ться	To smile
УМАЛИШЁННЫЙ	Mad, lunatic
УМИРА́ТЬ	To die
У́МНЫЙ	Clever, intelligent
УМ (а́, ы́)	Mind, intelligence
Универса́льный	Universal
Университе́т (а, ы)	University
Упа́док (дка)	The decline
УПЛА́ТА (ы, ы)	Payment
Уполномо́чивать	To authorize
Упомина́ть	To mention
УПОТРЕБЛЯ́ТЬ	To use, employ
УПРАВЛЕ́НИЕ (я, я)	Management
УПРАВЛЯ́ТЬ	To govern, manage
УПРАВЛЯ́ЮЩИЙ (его, ие)	Manager
Упрека́ть	To reproach
Упря́жка (и, и)	The team (e.g. of horses)
Уровень (вня, и)	Level
УРОЖА́Й (я, и)	Harvest
Уро́к (а, и)	Lesson
УСИ́ЛИЕ (я, я)	Effort
Усло́вие (я, я)	Condition
УСЛУ́ГА (и, и)	Service
УСПЕВА́ТЬ	Succeed
УСПЕ́Х (а, и)	Success
УСПЕ́ШНЫЙ	Successful
УСТА́ЛЫЙ	Tired, weary
Устра́ивать	To arrange
Уступа́ть	To yield
Усыновля́ть	To adopt
Утомля́ть	To tire
У́ТРО (а, а́)	Morning
У́ХО (а, у́ши)	Ear
УЧЕНИ́К (а́, и́)	Pupil, disciple
УЧЕ́НИЕ (я, я)	Teaching
УЧИ́ЛИЩЕ (а, а)	School
УЧИ́ТЬ	To teach
УЧИ́ТЬСЯ	To learn
УЧИ́ТЕЛЬ (я, я́)	Teacher
Учреди́ть	To found
Уще́рб (а, ы)	Damage, prejudice, injury

Ф, ф.

ФА́БРИКА (и, и)	Factory
ФАБРИКОВА́ТЬ	To manufacture
ФАКТ (а, ы)	Fact
ФЕ́РМА (ы, ы)	Farm
ФЕ́РМЕР (а, ы)	Farmer
Фигу́ра (ы, ы)	Figure
Фи́зика (и)	Physics
Физи́ческий	Physical
Фи́кция (и, и)	Fiction
ФИНА́НСЫ (plural)	Finance
ФИ́РМА (ы, ы)	Firm (n.)
Флаг (а, и)	Flag
Флот (а, ы)	Fleet, navy
Фона́рь (я́, и́)	Lantern
Фонта́н (а, ы)	Fountain
ФО́РМА (ы, ы)	Form, shape
Фортепиа́но (no declension)	Pianoforte
Фотографи́ровать	To photograph
Фрахт (а, ы)	Freight
Фронт (а, ы)	Front
ФРУКТ (а, ы)	Fruit
Фунт (а, ы́)	Pound
Фут (а, ы)	Foot (measure of length)

Х, х.

ХАРА́КТЕР (а, ы)	Character
ХВАЛИ́ТЬ	To praise
ХИМИ́ЧЕСКИЙ	Chemical
Хвост (а́, ы́)	Tail, rear

ХЛЕБ (а, ы and а́)	Bread
ХЛО́ПОК (пка)	Cotton
ХОДИ́ТЬ	To go, walk
Хлыст (а́, ы́)	The whip
Хозя́ин (а, –я́ева)	Host, master
ХОЛМ (а́, ы́)	Hill
ХОЛО́ДНЫЙ	Cold (adj.)
ХО́ЛОД (а, а́)	Cold (n.)
ХОЛОСТО́Й	Bachelor
ХОРО́ШИЙ	Good
ХОТЕ́ТЬ	To wish, desire, want
ХОТЯ́	Although
ХРА́БРЫЙ	Brave
Храм (а, ы)	Temple, church
ХРАНИ́ТЬ	To keep
Христо́с (—та́)	Christ
ХУ́ДШИЙ	Worst
ХУ́ЖЕ	Worse

Ц, ц.

ЦВЕТ (а, а́)	Colour
ЦВЕТО́К (а́, и́ and цветы́)	Flower
Целова́ть	To kiss
ЦЕ́ЛЫЙ	Entire, whole
ЦЕЛЬ (и, и)	Aim, target, purpose
ЦЕНА́ (ы́, ы)	Price, value
Цени́ть	To appreciate, to value
ЦЕ́ННОСТЬ (и, и)	Value
ЦЕ́ННЫЙ	Valuable
ЦЕНТРА́ЛЬНЫЙ	Central
ЦЕНТР (а, ы)	Centre
ЦЕПЬ (и́, и)	Chain
Це́рковь (кви, кви)	Church
ЦИВИЛИЗА́ЦИЯ (и, и)	Civilization
ЦИ́ФРА (ы, ы)	Figure (in numbers)
Цыплёнок (нка, —ля́та)	Chicken

Ч, ч.

ЧАЙ (я, и́)	Tea
ЧА́СТНЫЙ	Private, special, particular
ЧА́СТО	Often
ЧАСТЬ (и, и)	Part, share
ЧА́СТЫЙ	Frequent
ЧАС (а, ы́)	Hour
ЧАСЫ́ (plural)	Clock, watch
Ча́ша (и, и)	Cup, bowl
ЧЕЙ	Whose
ЧЕК (а, и)	Cheque
ЧЕЛОВЕ́К (а, люди)	Man
ЧЕЛОВЕ́ЧЕСТВО (а)	Humanity
Чепуха́ (и́)	Nonsense
ЧЕ́РЕЗ	Across, through
ЧЁРНЫЙ	Black
Черта́ (ы́, ы́)	Feature
ЧЕСТЬ (и)	Honour
ЧЕ́СТНЫЙ	Honest
ЧЕ́ТВЕРТЬ (и, и)	Quarter
ЧЕТЫРЕУГО́ЛЬНИК (а, и)	Square
Чини́ть	To repair
ЧИСЛО́ (à, а)	Number, date
ЧИ́СТЫЙ	Clean, pure
ЧИТА́ТЬ	To read
Чиха́ть	To sneeze
Член (а, ы)	Member
Чорт (а)	Devil
ЧТЕ́НИЕ (я, я)	Reading
ЧТО	What
ЧТО́БЫ	In order to
ЧТО́—БЫ	Whatever
ЧТО́—НИБУДЬ	Anything
Чу́вство (а, а)	Sense, feeling
ЧУ́ВСТВОВАТЬ	To feel
Чуде́сный	Wonderful
ЧУ́ДО (а, —деса́)	Wonder, miracle
Чужезе́мный	Foreign
ЧУ́ЖДЫЙ	Foreign, strange
ЧУЛО́К (лка́, и́)	Stocking
Чурба́н (а, ы)	Block
ЧУ́ТКИЙ	Keen (in the senses)
Чутьё (я́)	Instinct, flair

Ш, ш.

ШАГ (а́, и́)	Step
ША́ПКА (и, и)	Cap
ШАР (а, ы́)	Ball, sphere
Шёлк (а, а́)	Silk
ШЕРСТЬ (и, и)	Wool
ШЕРША́ВЫЙ	Rough
Ше́ствие (я, я)	March, procession
ШЕ́Я (и, и)	Neck
ШИ́НА (ы, ы)	Tire (on a wheel)
ШИРО́КИЙ	Broad, wide
Шить	To sew
ШКО́ЛА (ы, ы)	School
Шку́ра (ы, ы)	Skin, hide
ШЛЯ́ПА (ы, ы)	Hat
Шов (шва́, ы́)	Seam, stitch
ШУМ (а, ы)	Noise
ШУ́ТКА (и, и)	Joke

Щ, щ.

Ще́дрый	Generous
Щади́ть	To spare
ЩЕКА́ (и́, щёки)	Cheek
ЩЁТКА (и, и)	Brush

Э, э.

ЭКЗА́МЕН (а, ы)	Examination
ЭКЗАМЕНОВА́ТЬ	To examine
ЭКСПЕ́РТ (е́рта, ы)	Expert
Э́КСТРЕННЫЙ	Extra
ЭЛАСТИ́ЧНЫЙ	Elastic
ЭЛЕКТРИ́ЧЕСТВО (а)	Electricity
Э́ТОТ	This
ЭФФЕ́КТ (а, ы)	Effect

Ю, ю.

Ю́бка (и, и)	Skirt
ЮГ (а)	South
ЮЖНЫЙ	Southern
Ю́МОР (а)	Humour
Ю́НЫЙ	Youthful
ЮСТИ́ЦИЯ (и)	Justice

Я, я.

Я́блоко (а, и)	Apple
Явля́ться	To appear
Я́года (ы, ы)	Berry
Яд (а, ы)	Poison
ЯЗЫ́К (á, й)	Tongue, language
ЯЙЦО́ (á, а)	Egg
Я́ма (ы, ы)	Hole, pit
Я́РКИЙ	Bright
Ярлы́к (á, й)	Label
Я́СНЫЙ	Clear, distinct
Я́ЩИК (а, и)	Box, chest

LESSON NINE

Russian Texts and Translations

I. Extract from Maxim Gorky's book.

ДЕТСТВО
" CHILDHOOD "

В полутёмной. те́сной ко́мнате на полу́ под
In a half-dark narrow room on the floor under

окно́м лежи́т мой оте́ц, оде́тый в бе́лое
the window is lying my father, dressed in white

и необыкнове́нно дли́нный; па́льцы его́ босы́х ног
and unusually long; the fingers of his bare feet

стра́нно растопы́рены, па́льцы его́ ла́сковых
(are) strangely spread, the fingers of his caressing

рук, сми́рно поло́женных на грудь, то́же
hands, humbly placed on the breast, (are) also

кривы́е; его́ весёлые глаза́ пло́тно прикры́ты
crooked; his merry eyes (are) closely covered

чёрными кружка́ми ме́дных моне́т; его́ до́брое лицо́
with black circles of copper coins; his kind face

темно́ и пуга́ет меня́ нехорошо́ оска́ленными зуба́ми.
(is) dark and frightens me by unwell showing teeth.

Мать, полуго́лая в кра́сной ю́бке, стои́т на
Mother, half-naked in a red skirt stands on

колéнях, зачёсывая дли́нные мя́гкие во́лосы отца́
(her) knees, combing away long soft hair of father

со лба на заты́лок чёрной гребёнкой,
from forehead to the nape with black comb,

кото́рой я любил перепи́ливать ко́рки арбузо́в;
with which I liked to saw peels of water-melons;

мать непреры́вно говори́т что-то густы́м
mother uninterruptedly says something in deep

хрипя́щим го́лосом, ее се́рые глаза́ опу́хли и сло́вно
hoarse voice, her grey eyes swelled and seemingly

та́ют, стека́я ка́плями слёз.
are melting, trickling down by drops of tears.

Меня́ де́ржит за́ руку ба́бушка, — кру́гла
Me holds by hand grand-mother,—roun

большеголо́вая с огро́мными глаза́ми и смешны́м рыхлы
big-headed with huge eyes and a funny spong

но́сом; она́ то́же пла́чет, ка́к-то осо́бенно и
nose; she also weeps, somewhat peculiarly and

хорошо́ подпева́я ма́тери, дрожи́т вся и дёргае
well singing with mother, trembles all and pulls

меня́, толка́я к отцу́; я упира́юсь, пря́чусь
me, pushing towards father; I resist, hide mysel

за неё; мне бо́язно и нело́вко.
behind her; to me frightening and feel awkward.

Я никогда́ ещё не вида́л, что́бы больши́е пла́кали.
I have never yet seen that grown-ups cried,

и не понима́л слов неоднокра́тно ска́занных
and did not understand words, repeatedly spoken

ба́бушкой:
by grand-mother:

—Попроща́йся с тя́тей-то, никогда́ уж не
Say good-bye to daddy-then, never again not

увйдишь его́, по́мер он голу́бчик, не в срок,
will see him, died he little-pigeon not in due time,

не в свой час . . .
not in his hour . . .

Я был тяжело́ бо́лен,—то́лько что встал на́ ноги;
I was heavily ill,—just now stood up on legs;

во вре́мя боле́зни,—я э́то хорошо́ по́мню, — оте́ц ве́село
during illness,—I this well remember—father merrily

вози́лся со мно́ю, пото́м он вдруг исчéз,
was busy with me, afterwards he suddenly disappeared,

и его́ замени́ла ба́бушка, стра́нный челове́к.
and him replaced grand-mother, strange person.

—Ты отку́да пришла́? спроси́л я её.
Thou from where came (on foot)? asked I her.

Она́ отве́тила:
She answered:

—С ве́рху, из Ни́жнего,* да не пришла́,
From above from Nijny, and not came (on foot),

а прие́хала! По воде́-то не
but came (not on foot!) On the water-then they

хо́дят, шиш!
do not walk, fig!

Э́то бы́ло смешно́ и непоня́тно: наверху́, в
This was funny and incomprehensible: above in

до́ме. жи́ли борода́тые, кра́шеные персия́не,
the house there lived bearded painted Persians,

а в подва́ле ста́рый, жёлтый калмы́к продава́л
and in the basement an old, yellow Kalmuk was selling

овчи́ны.
sheep-skins.

По ле́стнице можно съе́хать верхо́м
On the stairs is possible to come down astride

на пери́лах, и́ли, когда́ упадёшь, скати́ться
on handrails or when falling down to glide down

кувырко́м, — э́то я знал хорошо́,—и при чём тут
topsy-turvy,—this I knew well,—but where (is) here

вода́? Всё неве́рно и заба́вно спу́тано.
water? All wrong and funnily confused.

—А отчего́ я шиш?*
And why (am) I a fig?

—Оттого́, что шуми́шь, — сказа́ла она́, то́же
Because thou makest noise,—said she, also

смея́сь.
laughingly,

*NOTE: шиш, as a noun means a fig (in a mocking or derogatory sense), and it is also the interjection—HUSH! Hence this untranslatable play of words in the grandmother's talk.' **Ни́жний** (adj.) means 'below': producing another untranslatable word-play. It is also the name of Nijni Novgorod.

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2 ИЗВЛЕЧЕНИЕ ИЗ ТРУДОВ ЛЕНИНА.

« ЧТО ДЕЛАТЬ »*

Напечатано впервые въ 1902г., цитируется по изданію « Дешёвой Библиотеки Госиздата » Москва. 1930. стр 40-41).†

Мы сказали, что социал-демократического сознания у рабочих и не могло быть Оно могло быть принесено только извне. История всех стран свидетельствует, что исключительно своими собственными силами рабочий класс в состоянии выработать лишь сознание трэд-юнионистское, т.е. убеждение в необходимости объединяться в союзы, вести борьбу с хозяевами, добиваться от правительства издания тех или иных необходимых для рабочих законов и т.п. Учение же социализма выросло из тех философских, историческких, экономических теорий, которые разрабатывались образованными представителями имущих классов, интеллигенцией. Основатели современного научного социализма, Маркс и Энгельс, принадлежали и сами, по своему социальному положению, к буржуазной интеллигенции. Точно так же и в России теоретическое учение социал-демократии возникло совершенно независимо от стихийного роста рабочего движения, возникло как естественный и неизбежный результат развития мысли у революционно-социалистической интеллигенции. К тому времени, о котором у нас идет речь, т.е. к половине 90-х годов, это учение не только было уже вполне сложившейся программой Группы « Освобождения Труда », но и завоевало на свою сторону большинство революционной молодежи в России.

EXTRACT FROM THE WORKS OF LENIN.

"What is to be done."

(English version taken from the generally approved translation published by Martin Lawrence Limited, by permission of International Publishers Co. Inc., p. 32-34)

We said that *there could not yet be* Social Democratic consciousness among the workers. This consciousness could only be brought to them from without. The history of all countries shows that the working class, exclusively by its own effort is able to develop only trade-union consciousness, i.e., it may itself realise the necessity for combining in unions, to fight against the employers and to strive to compel the government to pass necessary labour legislation etc.

The theory of Socialism, however, grew out of the philosophic, historical and economic theories .that were elaborated by the educated representatives of the propertied classes, the intellectuals. The founders of modern scientific Socialism, Marx and Engels, themselves belonged to the bourgeois intelligentsia.

Similarly, in Russia, the theoretical doctrine of Social-Democracy arose quite independently of the spontaneous growth of the labour movement, it arose as a natural and inevitable outcome of the development of ideas among the revolutionary Socialist intelligentsia. At the time of which we are speaking, i.e., the middle of the nineties, this doctrine not only represented the completely formulated programme of the Emancipation of Labour Group, but had already won the adhesion of the majority of the revolutionary youth in Russia.

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*The learner will find this passage difficult—Lenin is not an easy author

† The Russian in brackets is: Published first in 1902 and taken from the edition 'Cheap Library of the Gosizdat' (State Publishing Institution) Moscow, 1930, pp. 40-41

Таким образом налицо было и стихийное пробуждение рабочих масс, пробуждение к сознательной жизни и сознательной борьбе, и наличность вооруженной социал-демократическою теорией революционной молодежи, которая рвалась к рабочим. При этом особенно важно установить тот часто забываемый /и сравнительно мало известный факт/ что первые социал-демократы этого периода, усердно занимаясь экономической агитацией и вполне считаясь в этом отношении с действительно полезными указаниями тогда еще рукописной брошюры «Об агитации»—не только не считали ее единственной своей задачей, а напротив с самого начала выдвигали и самые широкие исторические задачи русской социал-демократии вообще и задачу ниспровержения самодержавия в особенности. Так, например, той группой петербургских социал-демократов, которая основала «Союз борьбы за освобождение рабочего класса», был составлен еще в конце

Hence, simultaneously we had both the spontaneous awakening of the masses of the workers—the awakening to conscious life and struggle, and the striving of the revolutionary youth armed with the Social-Democratic theories, to reach the workers. In this connection it is particularly important to state the oft-forgotten (and comparatively little known) fact that the early Social-Democrats of that period, *zealously carried on economic agitation* (being guided in this by the really useful instructions contained in the pamphlet "*Agitation*" that was still in manuscript) but they did not regard this as their sole task. On the contrary *right from the very beginning* they brought up the general historical tasks of Russian Social-Democracy, and particularly the task of overthrowing the autocracy. For example, the St. Petersburg group of Social-Democrats, which

1895 года первый номер газеты под названием «Рабочее Дело». Вполне готовый к печати этот номер был схвачен жандармами в набег с 8-го на 9-е декабря 1895 г. у одного из членов группы, Анат. Алекс. Ванеева, и «Раб. Делу» первой формации не суждено было увидеть света. Передовая статья этой газеты/которую, можетъ быть, лет через 30 извлечет какая-нибудь «Русская Старина» из архивов департамента полиции/обрисовывала исторические задачи рабочего класса въ России и во главе этих задач ставила завоевание политической свободы.*

was formed by the "League of the Struggle for the Emancipation of the Working Class" towards the end of 1895, got out the first number of the journal known as "*Rabocheye Dyelo.*" This number was completely ready for the press when it was seized by the gendarmes, who on the night of December 8, 1895, raided the house of one of the members of the group, Anatoly Alekseyevich Vaneyev, and so the original "Rabocheye Dyelo" was not fated to see the light. The leading article in this number which perhaps in 30 years' time some "Russkaya Starina" (Russian Antiquary) will discover in the archives of the Department of Police) described the historic tasks of the working class in Russia, of which the achievement of political liberty is regarded as the most important.

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* It will be noticed that the text is unaccented—deliberately so, to give an example of Russian as it is printed in a Russian book.

3. GULLIVER IN LILLIPUT

Jonathan Swift

I

THE WRITER GIVES SOME ACCOUNT OF HIMSELF AND FAMILY—WHAT FIRST MADE HIM GO TO SEA—HIS SHIP COMES TO DESTRUCTION—BY SWIMMING HE GETS SAFELY TO LAND IN THE COUNTRY OF LILLIPUT—IS MADE A PRISONER AND TAKEN INLAND

My father had a small property in Nottinghamshire; I was the third of five sons. He sent me to Emmanuel College in Cambridge at fourteen years old, where I was for three years, giving myself up completely to my books; but the money for keeping me, though it was very little, was overmuch for a small income, and I was put as a learner with Mr. James Bates, a noted medical man in London. I was with him for four years, my father from time to time sending me small amounts

ГУ́ЛЛИВЕР В ЛИЛЛИПУ́ТИИ.

Ионафа́на Сви́фта.

I.

Писа́тель даёт не́которые све́дения о себе́ и свое́й семье́ —Что пре́жде всего́ заста́вило его́ пойти́ в мо́ре —Его́ су́дно те́рпит круше́ние —Он достига́ет вплавь земли́ в стране́ лиллипу́тов—Его́ беру́т в плен и уво́дят внутрь страны́

Мой оте́ц име́л небольшо́е иму́щество в Но́ттингхемши́ре ; я был тре́тьим из пяти́ сынове́й. Он посла́л меня́ в Ко́лледж Эмануи́ла в Кэ́мбридже, когда́ мне бы́ло четы́рнадцать лет, где я про́был три го́да, отдава́ясь всеце́ло мои́м кни́гам ; но де́ньги на моё содержа́ние, хотя́ э́то бы́ло о́чень ма́ло, бы́ли сли́шком большо́й тя́жестью для ма́ленького дохо́да, и я был помещён в ка́честве ученика́ к Г-ну Дже́мсу Бэ́йтсу, изве́стному врачу́ в Ло́ндоне. Я про́был у него́ четы́ре го́да, причём мой оте́ц посыла́л мне от вре́мени до вре́мени небольши́е су́ммы

of money which I made use of for learning the science of the control of ships, and other parts of mathematics of value to those whose purpose it is to go on journeys. It was ever my belief that some day or other it would be my good chance to do this. When my time with Mr. Bates was ended, I went back to my father. There, with his help and that of his brother and some other relations, I got £40, with the hope of £30 a year in the future to keep me at Leyden. I did medical science in that town for two years and seven months, certain that it would be of use to me on long sea journeys. A short time after coming back from Leyden, with the help of my good teacher, Mr. Bates, I became medical man to the *Swallow*, of which Captain Abraham Pannell was the chief. I was with him for three years and a half, making a journey or two into the Levant and some other parts. When I came back, I made the decision to come to London, and in this I was supported by Mr. Bates, my teacher who said a good word for me to a number of persons under his care. I took part of a small house in the Old Jewry; and the suggestion being made that it would be better for me to make a change in my condition, I got married to Miss Mary Burton, second daughter of Mr. Edmund Burton, stocking trader in Newgate Street, with whom I was given 400 pounds.

But my good teacher Bates came to his end two years later, and I had only a small number of friends, so my business went from bad to worse; because, being an upright man, I was unable to make use of those tricks which are common among a great number of medical men. I got Mary's opinion and that of some of my friends, and made a decision to go to sea again. I was medical man in two ships, one after the other, and made a number of journeys, for six years, to the East and West Indies, by which I got some addition to the money I had. I made use of my free time in reading the best writers past and present, having at all times a great number of books with me; and when I was on land, I gave much time to getting a knowledge of the behaviour and qualities of the men and women of the country, and learning their language, which I was able to do very well, by reason of the power of my memory.

The last of these journeys was not a very happy one, and I got tired of the sea, and now had a desire to go back to my family. I went from the Old Jewry to Fetter Lane, and from there to Wapping, hoping to get business among the sailors, but I was unable to make any money. After hoping for three years that things would get better, I took a good offer from Captain William Pritchard, chief of the *Antelope*, who was going to the South Sea. We made a start from Bristol, May 4th, 1699, and our journey at first went very well.

де́нег. кото́рые я употребля́л для изуче́ния нау́ки управле́ния суда́ми и други́х часте́й матема́тики, це́нных для тех, кто име́ет наме́рение путеше́ствовать. Я всегда́ ве́рил, что мне когда́-нибудь посчастли́вится сде́лать э́то. Когда́ моё вре́мя у г-на Бэ́йтса зако́нчилось /истекло́/[2], я верну́лся к моему́ отцу́. Там, с по́мощью его́ и его́ бра́та и не́которых други́х ро́дственников я получи́л /доста́л/ со́рок фу́нтов, в наде́жде на дальне́йшие три́дцать фу́нтов в год в бу́дущем на моё содержа́ние в Ле́йдене. Я изуча́л медици́нскую нау́ку в э́том го́роде втече́ние двух лет и семи́ ме́сяцев, бу́дучи уве́рен, что она́ бу́дет мне поле́зна в до́лгих морски́х путеше́ствиях. Че́рез коро́ткое вре́мя по́сле возвраще́ния из Ле́йдена, с по́мощью моего́ до́брого учи́теля г-на Бэ́йтса, я сде́лался врачём на ЛА́СТОЧКЕ, команди́ром кото́рой был Капита́н Авраа́м Па́ннелль. Я про́был с ним три с полови́ной го́да, соверши́в одно́ и́ли два путеше́ствия в Лева́нт и не́которые други́е места́. Когда́ я верну́лся наза́д, я реши́л /при́нял реше́ние/ пое́хать в Ло́ндон, и в э́том меня́ поддержа́л мой учи́тель г-н Бэ́йтс, кото́рый замо́лвил /сказа́л/ за меня́ до́брое сло́во ря́ду лиц, кото́рых он лечи́л. Я снял /взял/ часть ма́ленького до́ма на Олд Джу́ри, и так как мне был дан сове́т, что бы́ло-бы лу́чше для меня́ сде́лать измене́ние в моём положе́нии, то я жени́лся на Мисс Мэ́ри Бэ́ртон, второ́й до́чери г-на Э́дмунда Бэ́ртона, биржево́го торго́вца на у́лице Нью́гэйт, за кото́рою мне да́ли четы́реста фу́нтов прида́ного.

Но мой до́брый учи́тель Бэ́йтс сконча́лся двумя́ года́ми поздне́е, а я име́л то́лько небольшо́е число́ друзе́й, так что мой дела́ пошли́ всё ху́же и ху́же, потому́ что, бу́дучи че́стным челове́ком, я не мог по́льзоваться таки́ми обма́нами, каки́е обы́чны среди́ большо́го числа́ враче́й. Я посове́товался с Мэ́ри и с не́которыми из мои́х друзе́й и при́нял реше́ние опя́ть уйти́ в мо́ре. Я был врачём на двух суда́х, одно́ за други́м, и соверши́л /сде́лал/ ряд путеше́ствий втече́ние шести́ лет в Восто́чную и За́падную И́ндию, чем сде́лал не́которое добавле́ние к деньга́м, кото́рые я име́л. Я по́льзовался мои́м свобо́дным вре́менем для чте́ния лу́чших писа́телей про́шлого и настоя́щего, име́я с собо́ю всё вре́мя большо́е число́ книг; а когда́ я был на су́ше, я отдава́л мно́го вре́мени ознакомле́нию с поведе́нием и ка́чествами мужчи́н и же́нщин страны́ и изуче́нию их языка́, что я мог /был в состоя́нии/ де́лать о́чень хорошо́ благодаря́ си́ле мое́й па́мяти.

После́днее из э́тих путуше́ствий бы́ло не о́чень счастли́вым, и я уста́л от мо́ря /и мо́ре мне надое́ло/, и тепе́рь у меня́ бы́ло жела́ние верну́ться к мое́й семье́. Я перее́хал с Олд Джу́ри на Фе́ттер Лэйн, а отту́да в Уо́ппинг, наде́ясь получи́ть пра́ктику среди́ моряко́в, но я не мог /не́ был в состоя́нии/ зарабо́тать каки́е бы то ни́ было де́ньги. Проведя́ три го́да в наде́ждах, что дела́ попра́вятся /бу́дут лу́чше/, я при́нял хоро́шее предложе́ние от Капита́на Уи́лльяма При́тчарда, команди́ра АНТИЛО́ПЫ, кото́рый отправля́лся /уходи́л/ к Ю́жному Мо́рю. Мы вы́ехали из Бристо́ля четвёртого ма́я ты́сяча шестьсо́т девяно́сто девя́того го́да, и на́ше путеше́ствие снача́ла шло о́чень хорошо́.

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[2] Alternative words or expressions in straight brackets / are of equally common, "everyday" usage.

There would be no point in troubling the reader with a full account of all the details,of our experiences in those seas. Let is be enough to say that on our journey from there to the West Indies, we were taken by a violent wind to the north-west of Van Diemen's Land. By an observation, we saw that we were 30 degrees 2 minutes south. Twelve of our men were dead through overwork and bad food; the rest were in a feeble condition. On the 5th of November, which was the start of summer in those parts. the weather being not at all clear, the seamen saw a great stone mass very near to the ship, and the wind was so strong that we were sent straight upon it, and were quickly broken in two. Six of the men, of whom I was one, let down the boat into the sea so as to get ourselves clear of the ship and the stone. We went, by my measuring, about nine miles, till we were unable to do any more work, having been made very feeble by the hard conditions on the ship. So we gave ourselves up to the motion of the waves, and in about half an hour the boat was overturned by a sudden wind from the north. That is the last I ever saw of the others in the boat or of those who got away on to the stone or were still in the ship, but I have no doubt they all went to their death.

I kept swimming in any direction, and was pushed forward by wind and.current. I frequently let my legs down but without touching earth ; but when I was almost at the end of my powers and unable any longer to put up a fight, I saw that I was in not very deep water, and by this time the wind had gone down. The slope was so small that I went almost a mile on foot before I got to the land, which I did at about eight at night. I then went forward for almost half a mile, but there were no signs of houses or of anyone living there; at least, I was in such a feeble condition that I did not see them. I was very tired, and with that, and the heat of the weather, and about half a pint of cognac which I took when I came away from the ship, I had a great tendency to go to sleep. I got down on the grass, which was very short and soft, and I had the deepest sleep I have every been in. It seemed to me I was sleeping for about nine hours ; because when I came awake it was daylight. I made an attempt to get up, but was unable to make a move; because, as I saw while stretched on my back, my arms and legs were strongly fixed on the two sides to the earth; and my hair, which was long and thick, was kept down in the same way. In addition, there were a number of thin cords across my body, from under my arms to the upper part of my legs. I was able to see only up; the sun was getting very warm and my eyes were troubled by the light Strange noises round me came to my ears , but in the position in which I was, I was able to see nothing but the sky In a little time I was

Бы́ло-бы неинтере́сно докуча́ть чита́телю по́лным отчёто /расска́зом/ о всех дета́лях /подро́бностях/ на́ших приключе́ни на тех моря́х. Доста́точно сказа́ть, что на на́шем пути́ отту́д в За́падную И́ндию мы бы́ли захва́чены жесто́ким ве́тром се́веро-за́паду от Ван Ди́менской Земли́. Наблюде́нием м установи́ли, что мы бы́ли на тридцати́ гра́дусах двух мину́та ю́жной широты́. Двена́дцать из на́ших люде́й у́мерли всле́дстви чрезме́рной рабо́ты и плохо́й пи́щи ; остальны́е бы́ли в сла́бо состоя́нии. Пя́того ноября́, что бы́ло нача́лом ле́та в те места́х, когда́ пого́да была́ соверше́нно не я́сной, моря́ увиде́ли большу́ю ка́менную ма́ссу о́чень бли́зко к корабл и ве́тер был так силён, что нас погна́ло пря́мо на неё, и м бы́стро переломи́лись на́двое. Шесть челове́к, среди́ кото́ры был я, спусти́ли ло́дку в мо́ре, та́к чтобы отойти́ пода́льш от корабля́ и ка́мня /скалы́/. Мы прошли́, по измере́ни о́коло девяти́ миль, пока́ оказа́лись /бы́ли/ не в состоя́ни бо́лее рабо́тать, бу́дучи о́чень осла́блены всле́дствие тяжёлы усло́вий на корабле́. Таки́м о́бразом мы о́тдались движе́ни волн, и приблизи́тельно че́рез полчаса́ ло́дка была́ перевёрнут внеза́пным ве́тром с се́вера. Э́то бы́ло в после́дний раз, что ви́дел други́х люде́й в ло́дке, и́ли тех, кото́рые перебра́лись н скалу́ и́ли бы́ли ещё на корабле́, но я не сомнева́юсь, что он все поги́бли.

Что каса́ется меня́, то я продолжа́л плыть ра́зных случа́йных направле́ниях, и ве́тер и тече́ние толка́л меня́ вперёд. Я ча́сто опуска́л но́ги, но не мог косну́ться дн /земли́/. Когда́-же я был почти́ у конца́ мои́х сил и не в состоя́ни до́лее боро́ться, я заме́тил /уви́дел/, что я был в не о́чен глубо́кой воде́, и к э́тому вре́мени ве́тер упа́л. Скло был так мал, что я прошёл почти́ ми́лю пешко́м, пре́жд чем добра́лся /дошёл/ до су́ши /земли́/, что я сде́лал о́кол восьми́ часо́в ве́чера. Зате́м я прошёл вперёд почт пол ми́ли, но там не́ было следо́в домо́в или кого́-либ живу́щего там ; по кра́йней ме́ре я был в тако́м сла́бо состоя́нии, что я их не ви́дел. Я был о́чень утомлён, благодаря́ э́тому и жа́ркой пого́де и почти́ пол пи́нте коньяку кото́рый я взял с собо́ю, когда́ сошёл с корабля́, у меня́ был больша́я скло́нность засну́ть. Я лёг на траву́, кото́рая был о́чень коротка́ и мягка́ /коро́ткая и мя́гкая/, и впал в са́мы глубо́кий сон, какои я когда либо име́л. Мне каза́лось, что спал о́коло девяти́ часо́в : потому́ что когда́ я просну́лся был дневно́й свет. Я сде́лал попы́тку встать /подня́ться/ но был не в состоя́нии сде́лать движе́ние ; потому́ что, как увиде́л, лёжа /растяну́вшись/ на спине́, мои́ ру́ки и но́ги был про́чно прикреплены́ с обо́их сторо́н к земле́ ; и мои́ во́лосы кото́рые бы́ли дли́нными и густы́ми, бы́ли притя́нуты вни таки́м-же о́бразом. В дополне́ние, бы́ло большо́е число́ то́нки верёвок поперёк моего́ те́ла, из под мои́х рук к ве́рхней част мои́х ног. Я мог /был в состоя́нии/ смотре́ть то́лько вверх со́лнце станови́лось о́чень горя́чим, и мои́ глаза́ беспоко́и свет. Стра́нные зву́ки вокру́г меня́ дошли́ /доходи́ли/ до мои ушей ; но в положе́нии, в кото́ром я находи́лся /был/, я н мог ви́деть ничего́ кро́ме не́ба. Че́рез коро́ткое вре́мя

conscious of some living thing moving on my left leg, and coming softly forward over my chest almost to my chin. Turning my eyes down as much as possible, I saw that it was a being in the form of a man not six inches high, with an archer's instrument in his hands and a long narrow box on his back At the same time I was conscious of at least 40 more of the same sort (as it seemed to me) coming after the first. I was greatly surprised, and gave such a loud cry that they all went running back in fear, and some of them, as they said to me later, were damaged by the falls they had in jumping from my sides to the earth. However they came back very quickly, and one of them, who came so far as to get a full view of my face, lifting up his hands and eyes in the warmest approval, gave a cry of *Hekinah degul!* in a high but clear voice. The others said the same words again and again, but I had no idea then what the sense of them was.

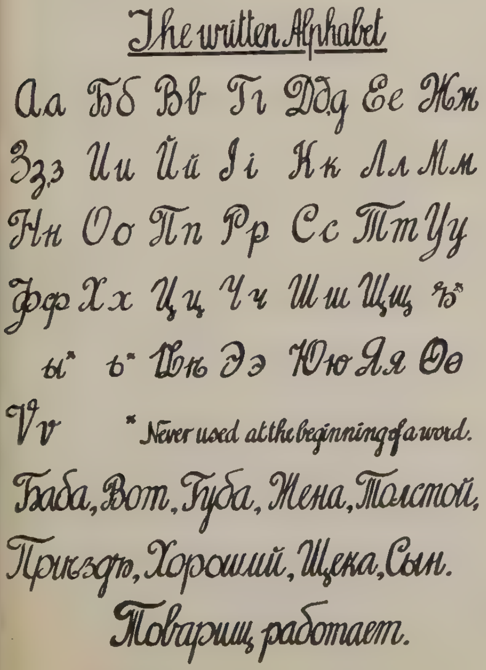
All this time, as will not be outside the reader's belief, I was greatly troubled. At last, fighting to get loose, I happily got the cords broken and the pins pulled out by which my left arm was fixed to the earth. Then, by lifting it up to my face, I saw the way they had made me a prisoner.

почу́вствовал, что кака́я-то жива́я вещь дви́галась по моéи ле́вой ноге́ и подходи́ла ти́хо вперёд на моéй груди́ почти́ к моему́ подборо́дку. Поверну́в глаза́ вниз наско́лько было возмо́жно, я уви́дел, что э́то было существо́ в ви́де челове́ка ни́же шести́ дю́ймов, с ору́дием лу́чника в его́ рука́х и дли́нным у́зким я́щиком на его́ спине́. В то́-же са́мое вре́мя я чу́вствовал, что по кра́йней ме́ре ещё со́рок того́ же ро́да (как мне каза́лось) шли за пе́рвым. Я был си́льно /о́чень/ удивлён и изда́л тако́й гро́мкий крик, что они́ все убежа́ли наза́д в стра́хе, а не́которые из них, как они сказа́ли мне позднée были ушй́блены от паде́ния, пры́гая с мои́х боко́в на зе́млю. Одна́ко они́ верну́лись /пришли́ наза́д/ о́чень ско́ро, и оди́н из них, кото́рый подошёл так бли́зко, что́бы ви́деть всё моё лицо́, подня́вши свой ру́ки и глаза́ в горя́чем восхище́нии, изда́л крик /воскли́кнул/ ХЕКИ́НА ДЕГУ́Л то́нким но я́сным го́лосом. Други́е сказа́ли /произнесли́ /те́-же са́мые слова́ опя́ть и опя́ть, но я не име́л тогда́ представле́ния о том, како́в был их смысл.

Всё э́то вре́мя, как чита́тель легко́ пове́рит, я был о́чень обеспоко́ен Наконе́ц, боря́сь, что́бы освободи́ться, я к сча́стью порвал верёвки и вы́рвал ко́лья, кото́рыми моя́ ле́вая рука́ была́ прикреплена́ к земле́. Зате́м подня́в её к моему́ лицу́, я по́нял, каки́м спо́собом они́ сде́лали меня́ пле́нником /взя́ли меня́ в плен/.

Alphabets

¶ *RUSSIAN HANDWRITING.*


The written Alphabet
Аа Бб Вв Гг Дд Ее Жж
Зз Ии Йй Іі Кк Лл Мм
Нн Оо Пп Рр Сс Тт Уу
Фф Хх Цц Чч Шш Щщ ъ*
ы* ь* Ѣѣ Ээ Юю Яя Ѳѳ
Vv * Never used at the beginning of a word.
Баба, Вот, Губа, Жена, Толстой,
Приѣздъ, Хороший, Щека, Сын.
Товарищ работает.

¶ *RUSSIAN ITALIC ALPHABET.*

1 *Аа,* 2 *Бб,* 3 *Вв,* 4 *Гг,* 5 *Дд,* 6 *Ее(Ёё),* 7 *Жж,* 8 *Зз,* 9 *Ии,* 10 *Йй,* 11 *Іі,* 12 *Кк,* 13 *Лл,* 14 *Мм,* 15 *Нн,* 16 *Оо,* 17 *Пп,* 18 *Рр* 19 *Сс,* 20 *Тт,* 21 *Уу,* 22 *Фф,* 23 *Хх,* 24 *Цц,* 25 *Чч,* 26 *Шш,* 27 *Щщ,* 28 *Ъъ,* 29 *Ыы* 30 *Ьь,* 31 *Ѣѣ,* 32 *Ээ,* 33 *Юю,* 34 *Яя,* 35 *Ѳѳ,* 36 *Ѵѵ,*

Compare the above alphabet with the handwriting on this page

¶ *RUSSIAN ORDINARY ALPHABET.*

1 Аа, 2 Бб, 3 Вв, 4 Гг, 5 Дд, 6 Ее, 7 Жж, 8 Зз, 9 Ии, 10 Йй, 11 Іі, 12 Кк, 13 Лл, 14 Мм, 15 Нн, 16 Оо, 17 Пп, 18 Рр, 19 Сс, 20 Тт, 21 Уу, 22 Фф, 23 Хх, 24 Цц, 25 Чч, 26 Шш, 27 Щщ, 28 Ъъ, 29 Ыы, 30 Ьь, 31 Ѣѣ, 32 Ээ, 33 Юю, 34 Яя, 35 Ѳѳ, 36 Ѵѵ,

HINTS FOR FURTHER STUDY

The student's next step in Russian studies must be to settle down to a course of reading, and in this he has a very wide choice. First he must provide himself with a good Russian-English dictionary such as that of Boyanus and Müller. He is hardly likely to need more grammar than this Course has provided. But, if it is wished to pursue the study, it is difficult to improve upon Nevill Forbes's Russian Grammar, or, perhaps still better, his First, Second, Third and Fourth Russian Books (published by the Clarendon Press). His Second Russian Book contains the best statement in English of the Russian verb—and it is the verb which presents the greatest difficulty of the language. The 'Basis and Essentials of Russian' by Charles Duff is useful for the pocket and the 'New Russian Grammar' by Anna H. Semeonoff is also an admirable book which can be thoroughly recommended.

Reading. Now for reading. *Any* elementary reader will do for a month or so, until the student has found his feet—that of Anna H. Semeonoff (published by Dent) can be recommended. Occasionally still to be found in the secondhand bookshops are Bondar's 'Russian Readers,' an excellent series of text books, annotated and accented, and in the old spelling. Messrs. Dent have published an edition of Pushkin's 'Captain's Daughter,' with an introduction, an abundance of explanatory notes, and a vocabulary by Anna H. Semeonoff. There could be no better book for the student who has had a little practice in reading short extracts—in Pushkin's tale, in spite of colourful and colloquial language, the Russian is not difficult. The experience of working right through a prose masterpiece—although not a long one—tends to create confidence. Here is literature in the full, and not in mere extracts. After a month or so of reading annotated texts, proceed to the series of Oxford Russian Plain Texts edited by Nevill Forbes. These include works by Tolstoi, Turgenev, Pushkin, Gogol, Dostoievski, Saltikov, Korolenko, Goncharov, Krilov, Lermontov—enough to keep you occupied for some time, and providing an admirable introduction to the vast ocean of Russian Literature. Read at least three of them.

By the time all this has been worked through, the plunge into Russian literature can be taken. The following books will provide a guide:

'A History of Russian Literature' (to 1881) by D. S. Mirsky.
'Contemporary Russian Literature' (1881–1925) by D. S. Mirsky.
'Soviet Russian Literature' (to 1943) by Gleb Struve.
'The Russian Novelists' by Janko Lavrin.
'Books on Soviet Russia' (1917–1942) by Philip Grierson.

In these books the reader will be presented with a prospect as vast as the mind of man. Russian Literature is so immense that the most anyone can ever hope to do is to read a part of it. Everyone must make his own selection and be guided by his own tastes.

Russian Classics. Sooner or later Tolstoi's 'War and Peace' or 'Anna Karenina' should be read. The best translation is that by Louise and Aylmer Maude (World's Classics). And then may be read the more difficult 'Brothers Karamazov' by Dostoievski (translation in Everyman Library) and Gogol's 'Dead Souls.' Among the contemporary writers to be read is Sholokhov's 'Quiet Flows the Don,' a great book in the Tolstoi tradition. The problem will always be to select from a superabundance of riches: no modern literature contains so much as Russian.

With these pointers the student may pursue his own way, in the full assurance that a study of the Russian Language will reap the richest of rewards and be worth all the effort that can be put into it. In the novel alone, the Russians have reached the highest peaks of literature, but in addition there is their poetry, their drama and, not least, their works on sociology and science. In the world in which we live all these are of high importance.